ANNUAL REPORT

1958

ROCKY MOUNTAIN
FOREST AND RANGE EXPERIMENT STATION

Fort Collins, Colorado   Raymond Price, Director

Forest Service - U. S. Department of Agriculture

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CALENDAR YEAR 1958

The Station maintains central headquarters at Fort Collins, Colorado, in cooperation with Colorado State University

(Not for publication)

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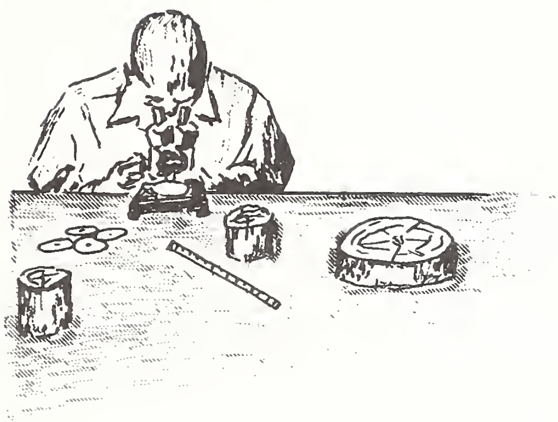


INTRODUCTION

A significant development in forest research at the Rocky Mountain Station in 1958 was the opportunity to begin research in four additional pressing forest research problem areas.

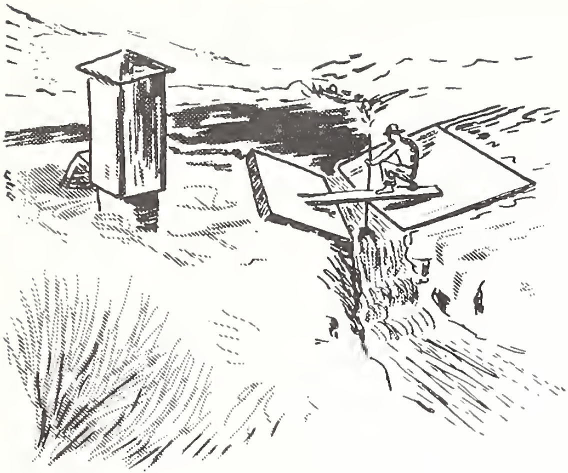
Heretofore, research in watershed management in the central Rockies largely has been confined to Colorado near Fraser. This year, as a result of favorable congressional action, it was possible to begin needed research in watershed management in the northern and southern reaches of the central Rockies -- in Wyoming and northern New Mexico. It is a modest beginning -- one scientist and an assistant are to be available at each location. However, it makes possible a start toward obtaining the necessary information needed to guide action programs.

In Wyoming, an experimental watershed area was "scouted" out in the high-elevation sagebrush areas in the vicinity of Dubois. Weirs and other necessary measuring devices have been established on three subwatersheds for pretreatment calibration. The main objective is to evaluate the effects of various methods of sagebrush treatment and control on snowpack and water yield and forage production. In New Mexico, available streamflow records for the Santa Fe watershed area are being analyzed, and this winter observations and measurements are being made of snowpack and snow behavior in the area with the view of the possible establishment of experimental watersheds for study.

The third new project started during the year was the extension of the Arizona watershed research activity to the mixed pine-fir forests in central Arizona. This forest type is the source of most of the perennial streams and is believed to contain the key areas for action to increase water yield. Research is underway in the White Mountain area of the Apache National Forest. Here sub-watersheds are being calibrated preliminary to treatment. Also, observations and records are being made this winter of snowfall and snowpack, as this may give clues to possible modification of the forest cover in an effort to increase water yield.

The fourth new project begun during the year is the beginning of research in forest insect problems in Arizona and New Mexico. During the past years control measures have been applied in the forests in an effort to curtail the tremendous timber losses by insects. But the measures taken and results obtained have been without specific foundation because information is lacking as to the species and nature of the insects involved. We now have an opportunity, although meager, to obtain through planned research, some of the facts and information regarding the insect species involved to guide and give assurance to future control measures.

Highlights of research findings on going projects during the past year are presented in the following pages. A more detailed account of the various research results is released through various publications. An annotated list of publications issued in 1958 is included in the Bibliography at the end of this report.



WATERSHED MANAGEMENT RESEARCH

Again we present our annual summary of watershed management research, starting high in the mountains and swinging down through the spruce-fir, the ponderosa pine, the woodlands type to the semidesert.

From the alpine zone, we are reporting a new snow study aimed at linking natural and artificial methods of snow accumulation. In the spruce-fir type there is emphasis on the effect of timber harvest and grazing on streamflow and sediment; we are also finding out how much of the precipitation is lost through interception, evaporation, and transpiration.

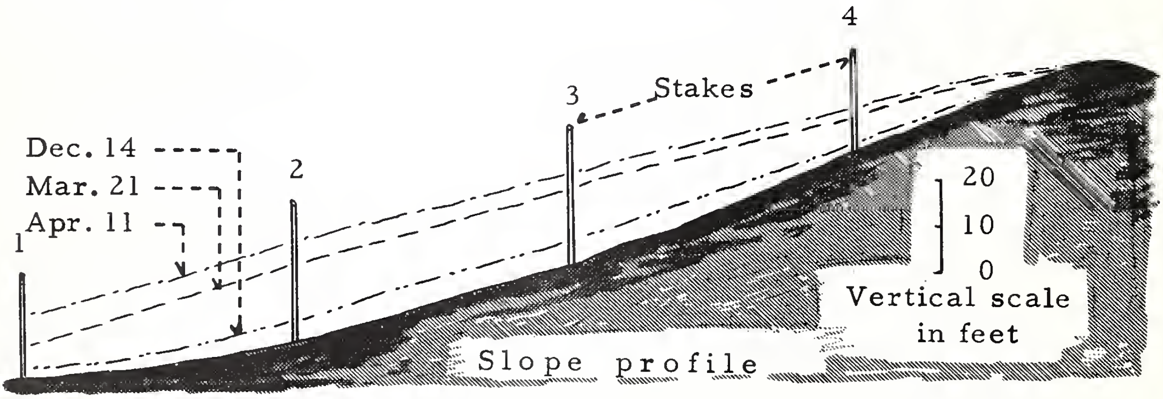
In the ponderosa pine type, we are starting a program to learn which structures are best for controlling gully erosion. There are also reports on precipitation-runoff relations from the Colorado Front Range and from the Black Hills.

In the woodlands type we are concerned not only with the impressive problem of high sediment yields but with the possibilities of getting more runoff by converting the brushy types to grassland.

We have new information on the amount of water used by phreatophytes -- water-wasting plants. We are getting at the problem of control not only by mechanical methods but also by studying growth habits and requirements in a search for natural means of replacing these plants with more useful ones.

Snow accumulation in the alpine

Figure WM-1. --Last winter a study was started to determine how fast snow accumulates in natural catchment basins in the alpine. The photograph shows some of the 71 stakes used to measure snow depths as they appeared on December 14. During the winter, snow accumulated at the four stakes in the foreground as follows:



On April 11 the snow was at its greatest depth for the season, with a maximum of 20 feet at stake 3. The sketch illustrates the tendency for more uniform accumulation late in the season, apparently as a result of the trees at the upper right having filled with snow and lost their efficiency as wind barriers. This suggests the possibility of increasing the amount of snow trapped in such areas by erecting a tall barrier on the uphill (windward) edge of the catchment area.

Water-yield increase maintained the third year after timber harvesting

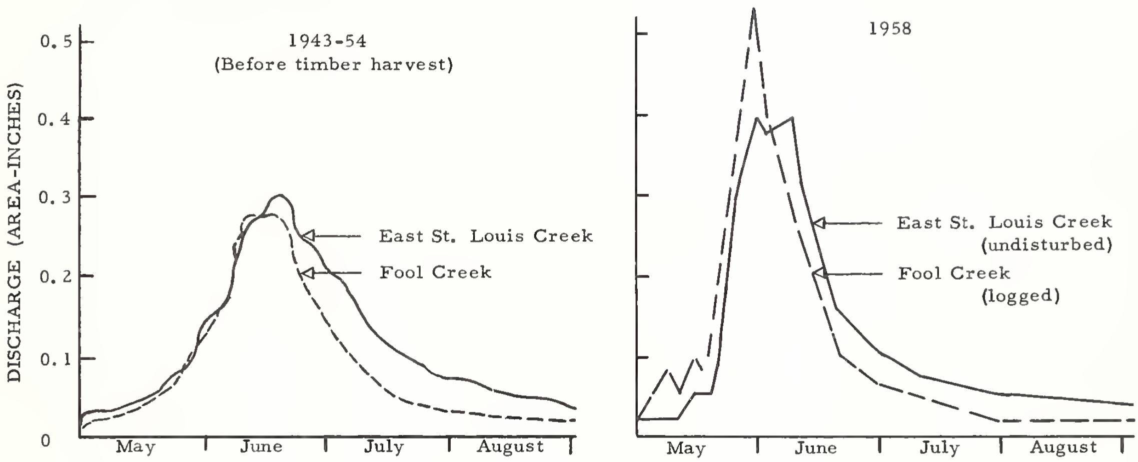


Figure WM-2. --Higher runoff during the first part of the melt season was again the main effect of strip-cutting on Fool Creek watershed. This can be seen by comparing 1958 streamflow on Fool and East St. Louis Creeks with the average flow before timber harvest. Another effect in 1958 was a peak flow 30 percent higher than predicted.

The year-by-year effect of timber harvesting on water yield is shown in the following tabulation:

Year	Water-yield increase (Area-inches)	Water-yield increase (Acre-feet)
1956	4.28	254
1957	3.38	200
1958	2.11	125

These increases are the amounts by which actual flow exceeded the flow that might have been expected if there had been no logging.

Sediment measurements during and after logging show slight erosion. Total deposition in a sediment basin for the 3 years following logging was 1.8, 3.4, and 2.1 cubic feet, respectively, per acre of watershed.

Snow deeper under heavily cut stands

The effect of different logging intensities on snow accumulation is shown in figure WM-3. The stands depicted here are mixed ponderosa pine - Douglas-fir, on north exposures in the Colorado Front Range. The moderately cut stand had 60 percent of the merchantable timber volume removed; the heavily cut stand, 100 percent.

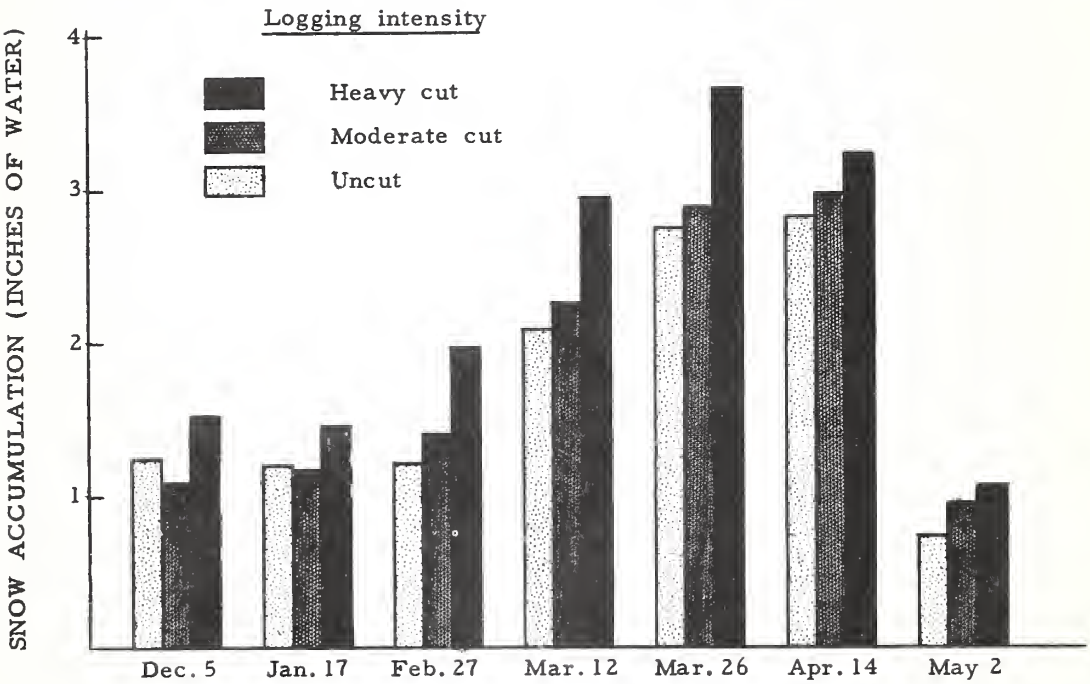


Figure WM-3. --Snow accumulation under heavily cut, moderately cut, and uncut stands of ponderosa pine - Douglas-fir, winter 1957-58.

The figure shows that:

1. At all times during the winter period the snow depths were greater in the heavily cut stand than in those moderately cut or uncut.
2. At the time of maximum accumulation (March 26) snow water content under the heavily cut stand exceeded that under the uncut stand by 28 percent; water content under the moderately cut stand exceeded that under the uncut stand by 4 percent.
3. Both intensities of logging increased snowmelt rate, so that the snow disappeared from all areas at very nearly the same time.

New technique for measuring evaporation in forest

Figure WM-4. --Cones of ice were suspended in low, intermediate, and high levels of a lodgepole pine tree to measure evaporation and melt gradients during the snowmelt season. Melt is represented by the weight of water caught in the can suspended below the cone; evaporation is the net weight loss of can + cone.

The tests show a generally greater rate of evaporation and melt in the canopy than at the surface of the snowpack. Evaporation and melt losses, expressed as percent of the original weight, were as follows during two 4-hour tests:

	Position on tree		
	Low	Intermediate	High
	- - - (Percent) - - -		
Evaporation loss:			
First test	4.7	5.6	6.0
Second test	10.0	9.9	11.1
Melt loss:			
First test	13.5	20.9	25.4
Second test	0	0	0

Replacement of moist-site forest by grass tested in Arizona

At the Sierra Ancha Experimental Forest in Arizona two watersheds are being managed for increased water yield and optimum timber production, respectively. On the North Fork of Workman Creek, 80 acres of white fir - Douglas-fir forest was cleared in 1958 and planted to perennial grass to learn the effect of such a conversion on streamflow and soil movement. First results are expected at the end of the water year, on September 30, 1959.

Figure WM-5. --North Fork of Workman Creek during clearing of white fir - Douglas-fir growing along the stream. Merchantable stand averaged about 13 M b.m. per acre, chiefly white fir, Douglas-fir, and ponderosa pine. Before clearing began the area shown in the picture was all in forest cover.

On the South Fork of Workman Creek management has been underway since 1953 to favor high-quality ponderosa pine. Despite a selective cutting of 36 percent of the original timber stand in 1953-56 and a 60-acre fire in 1957, there was no significant increase in streamflow in 1957 or 1958.

Figure WM-6. --Extracting soil cores for moisture determination in an aspen stand.

Aspen uses more water than spruce or grassland in western Colorado

Relative use of water by aspen, spruce, and grassland was found to be as follows:

	Inches of water used		
	1955	1957	Average
Aspen	20.94	17.14	19.04
Spruce	15.30	13.70	14.50
Grassland:			
Idaho fescue	10.14	--)	
Thurber fescue	9.86	--)	9.78
Mixed grass-weed	--	9.34)	

These values were determined on Black Mesa at an elevation of about 9,800 feet. Soil moisture was measured to a depth of 8 feet at the beginning and again at the end of the growing season (about 4-1/2 months). The difference in moisture content plus current precipitation was considered to be the amount of water used. Data are based only on sites where moisture content was at or above wilting point both spring and fall.

Snowmelt phenomena in Colorado mountain grassland

Figure WM-7. --Rills in the snowpack near the end of the melt period. During times of rapid melt, runoff is apparently channelized under these rills at the ground-snow interface. The rills begin to develop early in the melt period and become more distinct as snow depth decreases.

Figure WM-8. --A water table in the snow here has filled up the track behind the weasel. Such water tables are common during snowmelt, particularly in concave topography.

Relation of cover to runoff and sediment

Figure WM-9. --Snowmelt runoff is being measured on this western Colorado watershed (No. 5 below) as part of a study to learn how runoff and sediment production are affected by changes in plant and ground cover. The changes here are being brought about by different intensities of cattle grazing. Conditions in 1957, at the start of the study, were as follows:

	Watershed No. 4	Watershed No. 5	Watershed No. 6
Plant and ground cover on grasslands:	- - -(Percent) - - -		
Plant density index	26	22	19
Litter	28	38	39
Bare soil	40	38	41
Rock	6	2	1
Suspended sediment during snowmelt:	(Parts per million)		
Least	5	107	19
Most	765	1,830	1,183
Average	154	383	139
Runoff during snowmelt:	(Cu. ft. per sec. per sq. mi.)		
Peak discharge	27	36	29

Evaluation of erosion-control structures in Colorado

Structure and channel characteristics are being measured on many sites to provide a better understanding of why certain structures have been successful while others failed.

Figure WM-10. --Two 25-year-old structures are illustrated here. The log check dam at the left probably failed because it offered too much restriction to streamflow. The check dam below, on the other hand, offers much less restriction and is one of the most successful types. It is made of rocks and is reinforced by woven wire.

Eight percent of the precipitation on a Colorado watershed is converted to streamflow

Figure WM-11. --Streamflow measurements on Missouri Gulch. This 4, 600-acre watershed in the Colorado Front Range lies in the ponderosa pine - Douglas-fir type on soils derived from Pikes Peak granite. On the average, about 60 percent of the runoff occurs in April and May when the winter and spring snow melts. The yearly precipitation pattern is characterized by a peak in July and August. Eight percent of the average annual precipitation becomes streamflow.

Estimated precipitation and runoff the past 7 years are as follows:

Year	Total precipitation (Inches)	Total flow (Inches)	Precipitation becoming streamflow (Percent)
1952	15.57	1.131	7.26
1953	18.52	.922	4.98
1954	12.86	.489	3.80
1955	17.39	1.039	5.97
1956	13.37	.531	3.97
1957	27.05	3.627	13.41
1958	19.04	2.097	11.01
Average	17.69	1.405	7.94

Fourteen percent of the precipitation on a Black Hills watershed is converted to streamflow

Some interesting comparisons can be made between precipitation-streamflow relations on the Rapid Creek watershed and those previously described for Missouri Gulch, in the Colorado Front Range. Precipitation was about a fifth higher on Rapid Creek, averaging 21.46 inches per year; however, streamflow was twice as great, averaging 3.06 inches per year. This streamflow is 14 percent of the precipitation.

Further details of Black Hills precipitation are as follows: Precipitation varies from about 18 to 28 inches a year as compared with 12 to 14 inches for the surrounding plains; from 57 to 69 percent of annual precipitation falls during the growing season, which extends from about the middle of May to near the end of September.

Average monthly precipitation and streamflow are depicted in figure WM-12. This shows that in most years precipitation and streamflow are at their lowest during the winter months. A gradual buildup follows, and precipitation reaches a seasonal maximum in May or June, depending on location. Streamflow peaks at about the same time. Despite the differences in precipitation patterns, this timing of streamflow in the Black Hills is similar to that of streams in the Rocky Mountains, where peak flows result from melting of the winter snowpack.

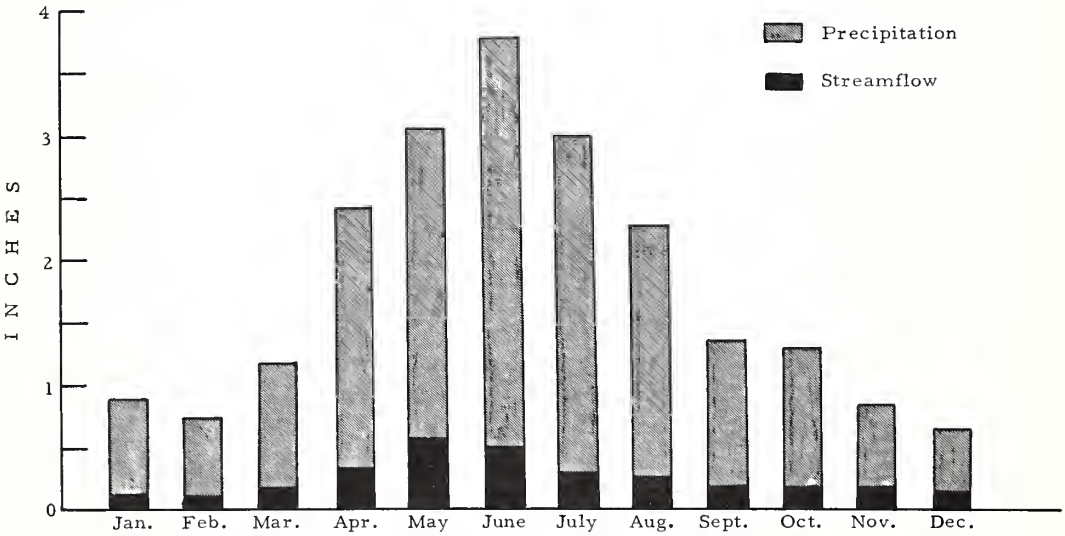


Figure WM-12. --Average monthly precipitation and streamflow on Rapid Creek in South Dakota for the period 1915-42.

Figure WM-13. --Rainfall interception measurements in a thinned ponderosa pine plot in the Black Hills.

In South Dakota and Arizona ponderosa pine intercepts 11 to 25 percent of rainfall

Studies of rainfall interception by pole-sized ponderosa pine have been made in the Black Hills, South Dakota (fig. WM-13) and in central Arizona. Some of the findings are summarized in table WM-1.

Table WM-1. --Relationships between interception and stand basal area in ponderosa pine. Data for Black Hills, South Dakota, are for the period September 30, 1957 to October 1, 1958; Arizona data for July 6 to October 28, 1957.

Location	Gross rainfall	Through-fall	Stem-flow	Net rainfall[1]	Basal area	Inter-ception[2]
	Inches				Sq. ft. per acre	Percent
Black Hills, South Dakota						
Thinned plot (fig. WM-13)	22.77	19.76	0.04	19.80	80	13
Unthinned plot	22.77	17.03	.08	17.11	171	25
Arizona						
Fort Valley	5.30	4.64	.03	4.67	48	12
	9.24	7.81	.25	8.06	138	13
	6.46	4.73	.22	4.95	266	23
James Canyon	7.26	6.38	.07	6.45	61	11
	6.73	5.26	.22	5.48	120	19
	7.08	5.48	.36	5.84	278	18
Beaver Creek	8.50	7.38	.15	7.53	90	11
	9.00	6.60	.13	6.73	166	25
	9.49	6.78	.79	7.57	256	20

[1] Through fall + stemflow.

[2] $\frac{\text{Gross rainfall - net rainfall}}{\text{Gross rainfall}}$

Figure WM-14. --Litter measurements in ponderosa pine showed that age of the stand was more closely related to litter weight than number of stems per acre of basal area.

Litter accumulation under Arizona ponderosa pine is 4 to 21 tons per acre, depending on age and density of stand

Table WM-2. --Litter weight in young ponderosa pine plots, Arizona

Plot location	Density: Stems per acre	Density: Basal area per acre[1]	Age	Oven-dry weight of litter per acre
	Number	Square feet	Years	Tons[2]
		Poles		
U. S. 89A	190	61	30	3.7 ± 0.2
Fort Valley	160	48	32	4.9 ± .1
U. S. 89A	550	120	47	10.9 ± .2
Beaver Creek	310	90	48	5.8 ± .4
U. S. 89A	1,590	278	52	13.2 ± .3
Fort Valley	380	138	59	10.4 ± .6
Beaver Creek	360	166	62	18.4 ± .8
Fort Valley	720	266	63	17.4 ± .6
Beaver Creek	840	256	70	21.1 ± .6
		Seedlings-Saplings		
Fort Valley	5,140	155	39	8.5 ± .3
Fort Valley	18,470	228	39	10.3 ± .1

[1] Measured at d.b.h. for poles and at stump height for seedlings-saplings.

[2] 95 percent confidence interval estimates were computed for each density class.

Soil level builds up one-fourth inch in a year on the San Luis watersheds of New Mexico

Figure WM-15. --Measurement of soil-elevation transects with engineer's level and rod. On 6 out of 7 such transects there was an aggradation, or buildup, of the soil level. This amounted to one-fourth inch on the average during the past year and was attributed to a total rainfall of 7.05 inches, 4 inches of which fell in a single, 2-day storm. Apparently soil is eroding from the uplands and bluffs and being gradually deposited over these lower-lying lands.

Despite the apparent buildup of the soil level, a great deal of sediment is carried on down to the reservoirs below -- annual depositions as great as 1.34 acre-feet per square mile have been measured. Most of this is believed to come from gullies rather than upland slopes. The most sediment per unit area came from the watershed with the greatest number and length of gullies, and the watershed with the least gullies produced the least sediment. Through a better understanding of these soil-movement processes, we hope to learn which sites have the greatest need for erosion control.

Runoff and sediment measurements
started in the chaparral type

As the first step in a program to study chaparral and its control in Arizona, five watersheds have been selected and instrumented -- two of these are on Copper Creek along the Whitespar Highway south of Prescott; three others are on the southwest side of Mingus Mountain. Stream-gage construction and runoff characteristics are illustrated in figures WM-16 and WM-17. An early finding has been the high rate of sediment movement on coarse-textured soils of the Mingus areas. Measurements in the weir pond following storms of 1.75 and 1.30 inches showed sediment contributions of approximately 500 cubic yards per square mile.

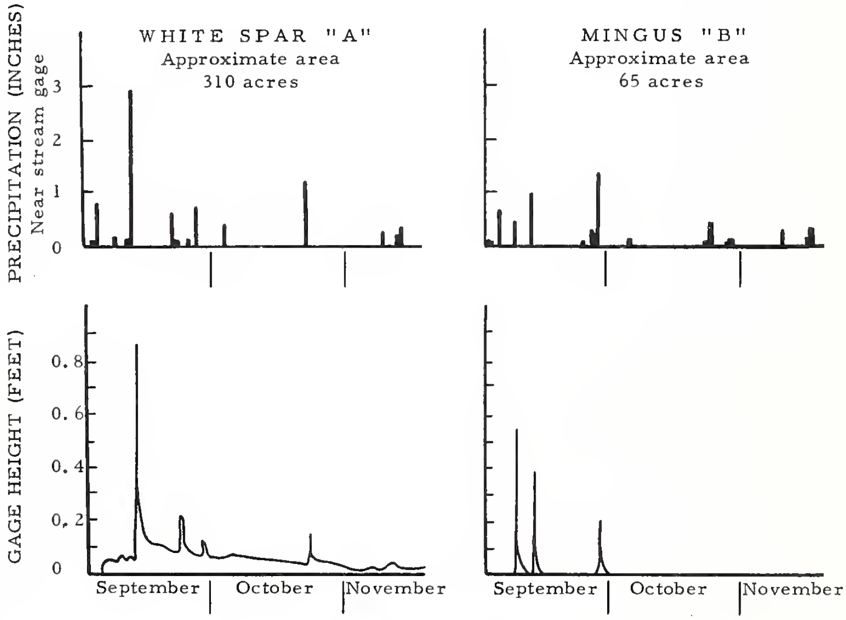


Figure WM-16. --(Above) Streamflow from Mingus and Whitespar watersheds. Whitespar has longer drain-out periods, and flows are not as flashy.

Figure WM-17. --(Right) Type of stream gage installed on chaparral watersheds. San Dimas flume measures high flows; V-notch weirs, low flows.

Some characteristics of Arizona chaparral

Other studies in the chaparral type in Arizona have provided information on composition of the stands and the effect of protection from grazing.

Composition of the ground cover on chaparral watersheds of the 3-Bar wildlife study area on the Tonto National Forest is shown in the following tabulation. Livestock grazing has been excluded from this area for 13 years.

Vegetation	Actual cover intercept on watershed--		
	B	C	D
	(Percent)		
Shrub live oak	27.9	27.5	30.2
Palmer oak	6.9	5.8	6.6
Emory oak	1.6	4.5	6.5
True mountainmahogany	12.8	8.8	6.9
Sugar sumac	4.0	10.1	4.8
Pointleaf manzanita	0	5.7	4.9
Other shrubs	12.3	8.7	10.4
Forbs (all)	--	2.2	.8
Grasses (all)	.1	.4	1.5
Total	65.6	73.7	72.6

A characteristic of these stands is the high proportion (about 40 percent) of shrub live oak. Other areas in the chaparral are known to contain even more of this species, for example, the Prescott area, where oak was found to comprise 65 to 80 percent of the total cover.

Nineteen years' protection from livestock grazing has resulted in only minor changes in chaparral types near Skull Valley and Kirkland. These changes were mostly in the nature of minor establishment and death loss of shrubs and half-shrubs.

Evapotranspiration rates of tamarisk

Figure WM-18.--This apparatus was developed this year to measure water use by phreatophytes. The 10- by 10-foot polyethylene tents were set up over areas of phreatophyte vegetation and evapotranspiration losses measured with an infrared gas analyzer.

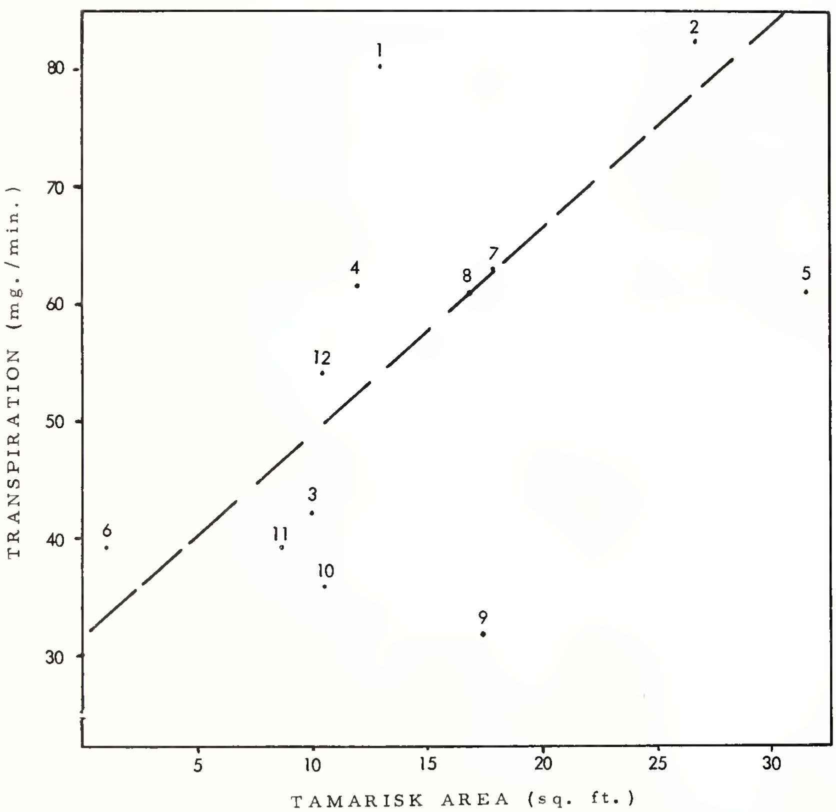


Figure WM-19.--Evapotranspiration rates of 12 tamarisk plots were between 32 and 82 mg. per minute, depending on extent of the tamarisk. The area occupied by tamarisk was considered to be the area of the shadows cast by tamarisk plants at about noontime.

Tamarisk seedlings develop slowly for the first 5 weeks

Tamarisk seedlings were sown in 9 clay pots in the greenhouse at Tempe, Arizona. Starting at 2 weeks, and weekly thereafter, a pot was chosen at random, the shoot growth measured, and the soil carefully removed for root measurement. The tabulation which follows shows that for the first 5 weeks the roots did not grow far below the soil surface, indicating that young seedlings may be highly susceptible to kill by drying of the soil surface during that period. By the ninth and tenth weeks the roots had become too entangled to measure accurately.

Age in weeks	Length: Shoots (cm.)	Length: Roots (cm.)	Age in weeks	Length: Shoots (cm.)	Length: Roots (cm.)
2	0.5	1.5	7	7.9	10.2
3	1.2	2.8	8	11.7	15.6
4	1.9	4.0	9	10.7	--
5	3.2	5.1	10	21.8	--
6	6.6	6.3			

Tamarisk root cuttings sprout less than stem cuttings

Sprouting was much greater from stem cuttings than from root cuttings during all the months measurements were taken. No shoots were developed from any of the root cuttings, though many of those planted in the spring did develop roots. The following tabulation shows the percentage of stem and root sprouts developing from cuttings made at different months of the year:

Month	Stem cutting development: Shoots	Stem cutting development: Roots	Root cutting development: Shoots	Root cutting development: Roots
	(Percent)		(Percent)	
March	92	89	0	7
April	97	100	0	33
May	72	92	0	30
June	92	92	0	0
August	88	92	0	0
September	90	92	0	0

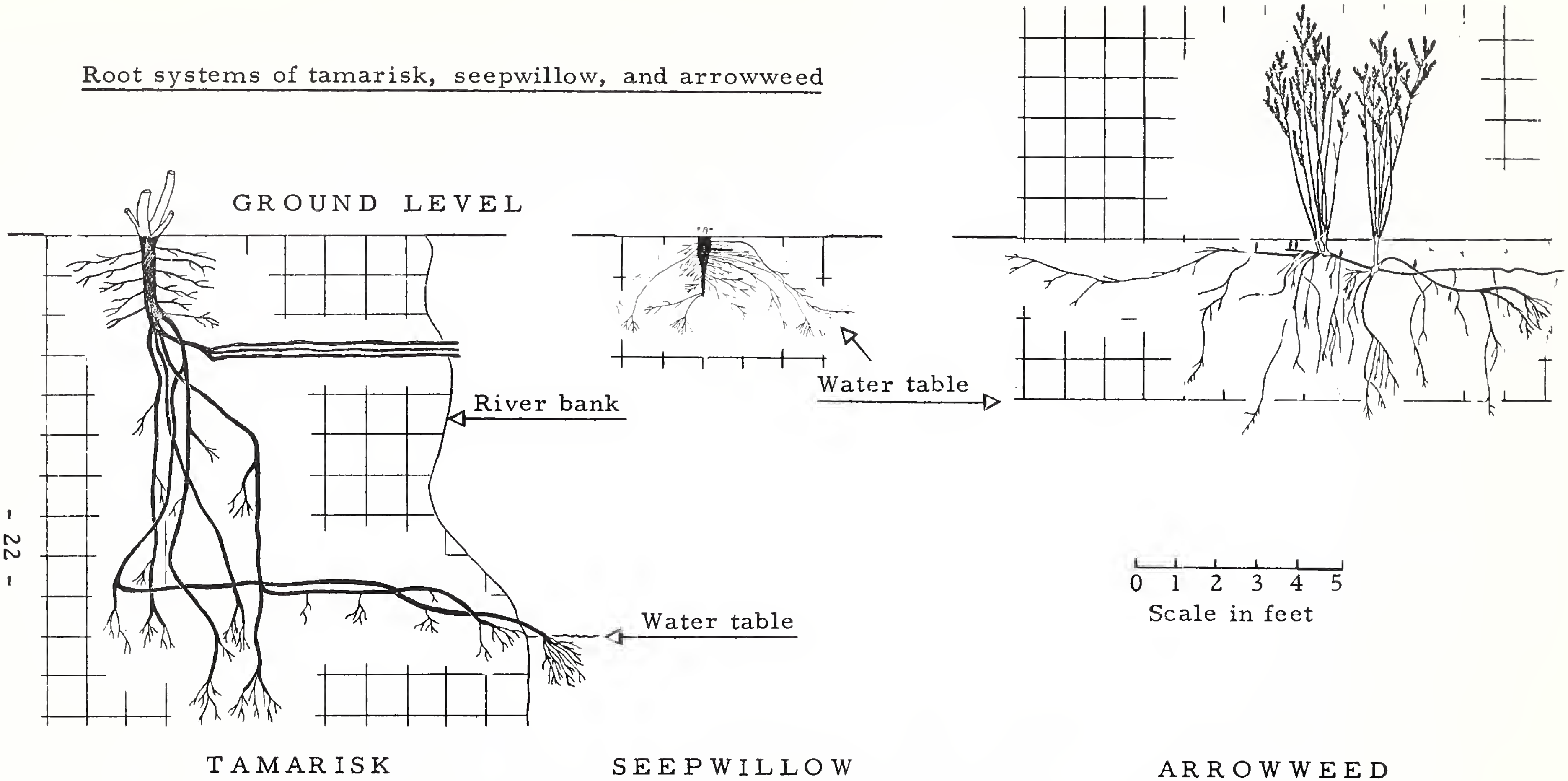


Figure WM-20. --Root systems of important phreatophytes were studied along the Salt River. The tamarisk plant was 17 feet high and the seepwillow 13 feet. Note that the tamarisk and seepwillow have definite taproot systems, while arrowweed has a lateral system. Roots of all three plants extend into the water table.

Root plow successfully controls tamarisk

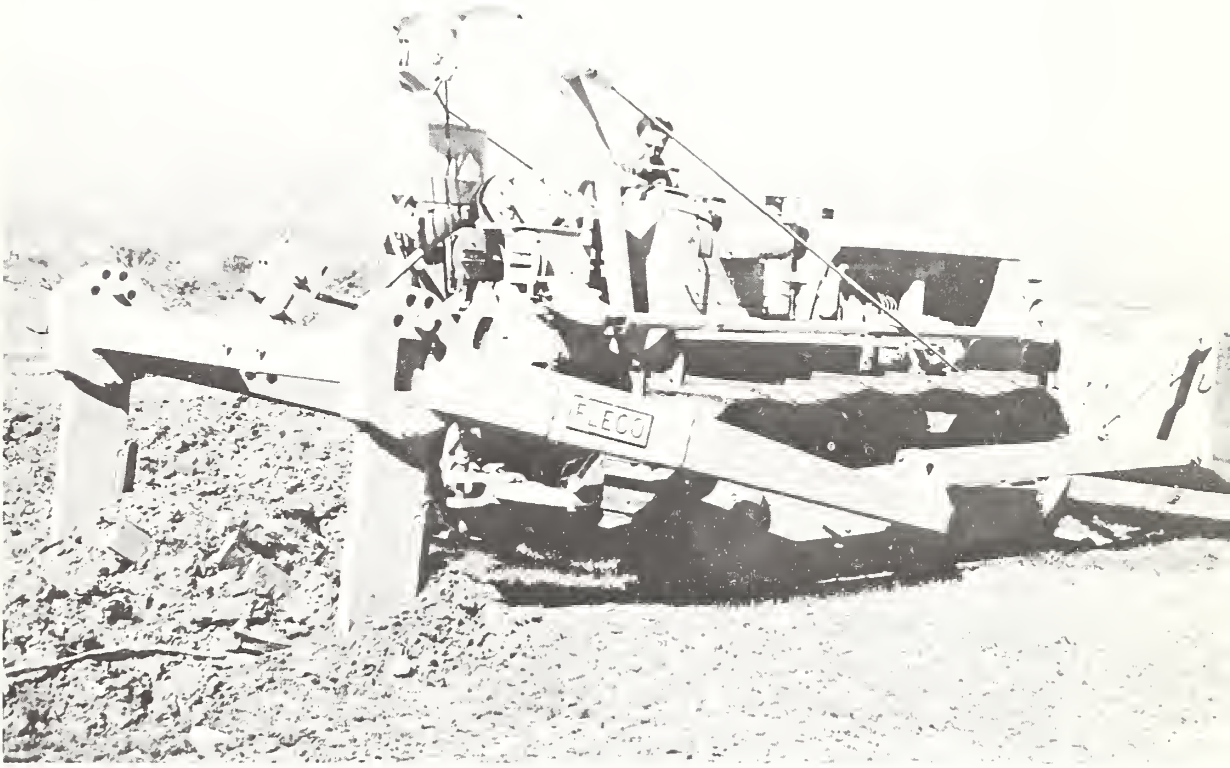


Figure WM-21. --The effectiveness of this root plow for eradicating mature stands of fivestamen tamarisk was tested this year near Gillespie Dam on the Gila River, Arizona. Equipment consisted of a root plow installed on a crawler-type tractor. The root plow is pulled underground at 12 to 18 inches below the soil surface, thus cutting the shrubs below the sprouting root crown.

Four months after clearing only a few scattered shrubs were alive. These were accidentally missed during the clearing operation. Sprouts grew from both the root crown and stems of these leftover shrubs, and amounted to about 35 sprouting plants per acre. No sprouting was observed from roots cut 6 inches or more below the ground surface.

RANGE MANAGEMENT RESEARCH

SEMIDESERT GRASS-SHRUB RANGES

Hauling water for range cattle in southern Arizona cost 3 cents per cow day

Water was hauled to 75 cattle for a 125-day period at a cost of 3 cents per cow per day on the Santa Rita Experimental Range. The haul was made with a truck that carried 1,400 gallons a trip. In all, 75,000 gallons of water was hauled, requiring 145 hours' labor, 1,000 truck miles, and 160 gallons of gasoline. The average cost of hauling was $0.0038 per gallon of water for the 9-mile haul.

Benefits from hauling water included: (1) reduced feed bills, (2) reduced grazing around permanent water, (3) better use of remote parts of the range (fig. R-1), and (4) better care of livestock because the cattle were seen more often.

Mesquite seeds remain viable in soil for 10 years

Seed of velvet mesquite (*Prosopis juliflora* var. *velutina*) buried in 1948 on the Santa Rita Experimental Range were removed from the soil in 1958 and their viability determined. One seed had recently sprouted and the seedling was alive at the time the seed cache was excavated. Other seeds germinated after their seed coats were scarified. Viability of seeds in pod segments buried in soil was more than twice as high as for seeds that had been buried without the pod.

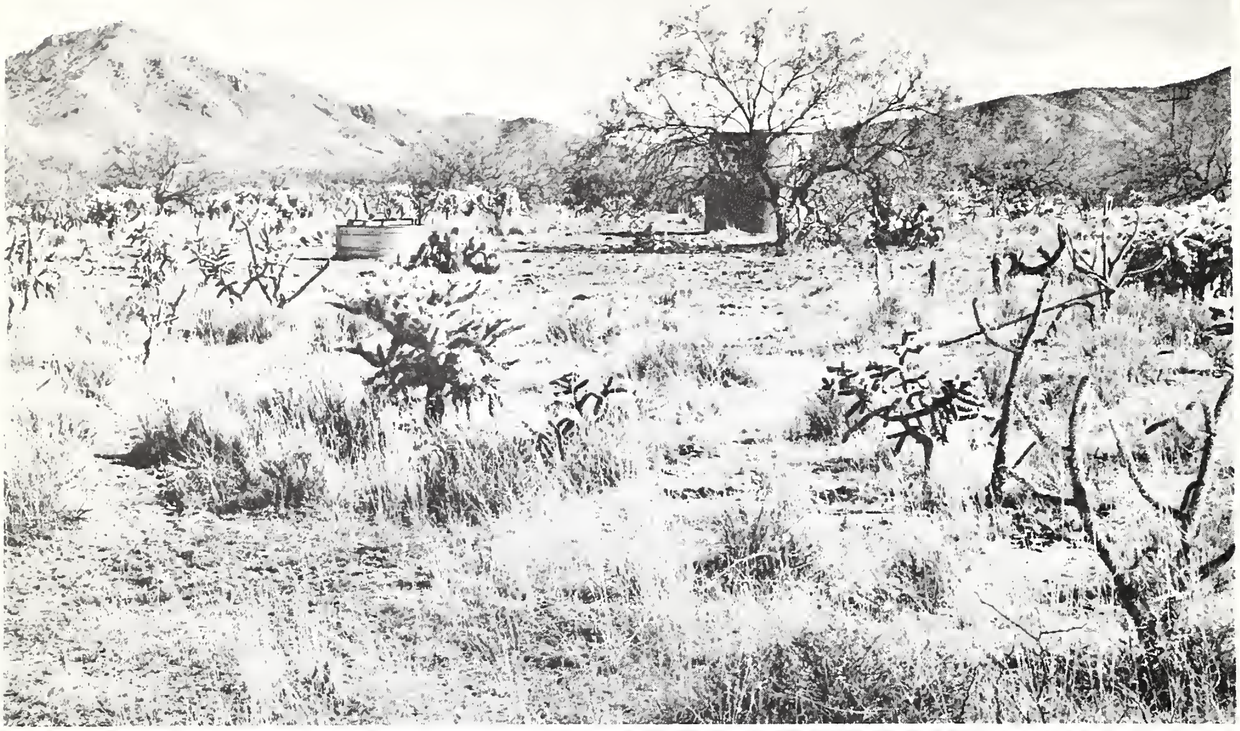


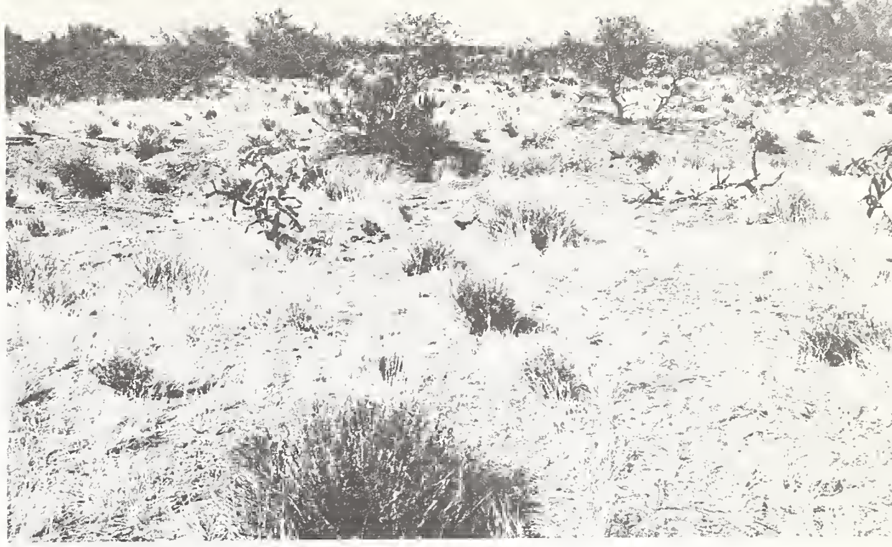
Figure R-1. --Water was stored in a 3,000-gallon tank connected to the trough. Flow to the trough was regulated by a float valve. Santa Rita Experimental Range, Arizona.

Burning reduced burroweed and increased annual grass on semidesert range

Burning, undertaken to determine whether the flush of annual grass growth could be used as fuel to control shrubs on grass-shrub ranges, reduced burroweed (*Aplopappus tenuisectus*) 85 percent on the Santa Rita Experimental Range. In 1958, 3 years after the burn, burroweed had increased on the burned plots but was still 70 percent below the pre-burn number (fig. R-2). Other shrubby species, including cacti (*Opuntia* spp.) and mesquite, were little affected by the burn.

Annual grass production in 1954 was approximately 200 pounds per acre on plots to be burned and on control plots. Following the burn in 1955 annual grass production was about equal on the burned and unburned plots. In 1958 annual grass production on the burned plots was 28 percent higher than on the unburned plots. Needle grama (*Bouteloua aristidoides*) and annual three-awn (*Aristida adscensionis*) were the principal species of annual grass. Perennial grasses were sparse.

Before burning, showing numerous burroweed plants.



One year after burning, showing good kill of burroweed, and poor annual grass growth due to low rainfall.

Three years after burning, showing good annual grass growth due to favorable summer rainfall.

Figure R-2. --Repeat photographs showing changes in number of burroweed and growth of annual grasses following a controlled burn.

CHAPARRAL AND WOODLAND RANGES

Shrub live oak difficult to kill by burning

Burning the aerial part of shrub live oak (*Quercus turbinella*) for five consecutive years in Arizona reduced the number of live stems to less than one-third of the original number. Burning less frequently has increased the number of sprouts. Individual plants of several shrub species of the chaparral type were burned with a torch that generated temperatures up to 1,500°F. The parts above ground were completely consumed. The plots were first burned in 1953. Just before each burn, the average number of live sprouts per original stem was determined. Numbers of sprouts from original stems for the oak are as follows:

Treatment	1954	1955	1956	1957	1958
	(No. sprouts per original stem)				
Burned each year	5.89	2.70	3.08	1.34	0.31
Burned every second year	--	8.09	--	7.51	--
Burned every third year	--	--	4.21	--	--
Burned every fourth year	--	--	--	4.65	--
Burned every fifth year	--	--	--	--	4.64

Desert ceanothus (*Ceanothus greggii*), hollyleaf buckthorn (*Rhamnus crocea*), pointleaf manzanita (*Arctostaphylos pungens*), and larchleaf goldenweed (*Aplopappus laricifolius*) were completely killed by a single or, at most, two burns. There was no consistent response in sprouting of Wright silktassel (*Garrya wrightii*) and skunkbush (*Rhus trilobata*) to burning.

Perennial grasses increase with shrub elimination in central Arizona

Significant increases of perennial grass density resulted from eliminating shrubs on experimental areas in the chaparral type on the Sierra Ancha Experimental Forest near Globe, Arizona. Shrubs were poisoned in 1954. Changes in grass density on six different sites within treated and untreated check areas by 1957 are shown in the following tabulation:

Site classification	Untreated	Treated	Difference
	- - - - -	(Percent)	- - - - -
Grass type:			
South aspect	3.82	3.58	-0.24
North aspect	4.14	4.72	0.58
Shrub type:			
South aspect	1.79	5.48	3.69
North aspect	1.08	6.54	5.46
East aspect	.15	1.70	1.55
Half-shrub type:			
East aspect	.15	2.15	2.00

Better rainfall in 1957 as compared with 1954 resulted in increased grass density on both treated and untreated areas. Changes in grass density on grassland sites were much the same on all areas. However, on shrub and half-shrub types, grass density increased 3 to 15 times more where the shrubs had been poisoned than on check areas. The greatest increases were on sites dominated by shrubs on a north aspect, followed by a south aspect and east aspects.

Weeping lovegrass decreasing on burned and seeded chaparral site

Weeping lovegrass (Eragrostis curvula), which was seeded on the 1952 Pinal Mountain burn near Globe, Arizona, immediately following the fire, has decreased markedly after reaching a peak in 1956 (table R-1). Many large plants of lovegrass had died or were much reduced in basal diameter in 1958. Moreover, lovegrass was not reproducing. This is not the result of drought as rainfall during 1957 and 1958 was above average. The reduction was observed on both grazed and ungrazed areas. Shrubby vegetation, meanwhile, has continued to increase on both grazed and ungrazed areas.

Amount of weeping lovegrass inversely related to density of oak brush

The density and vigor of 1-year-old weeping lovegrass seedlings increased as density of shrub live oak (Quercus turbinella) was reduced (fig. R-3). In 1957, all species of shrubs

Table R-1. --Changes in vegetation density following fire, 1952, Pinal Mountain Burn

Treatment and year	Basal area: Weeping lovegrass	Basal area: Other grasses	Crown cover: Shrub live oak	Crown cover: Other shrubs	Total
	- - - - -	Percent	- - - - -		
Grazed					
1952	0.51	0	20.40	2.97	23.88
1953	.77	0	23.52	4.35	28.64
1956	.46	0	33.93	9.74	44.13
1958	.08	0	36.37	13.18	49.63
Ungrazed					
1952	.68	0.04	18.46	3.56	22.74
1953	1.01	.05	20.35	4.59	26.00
1956	1.25	.03	30.27	6.78	38.33
1958	.39	.05	31.04	7.43	38.91

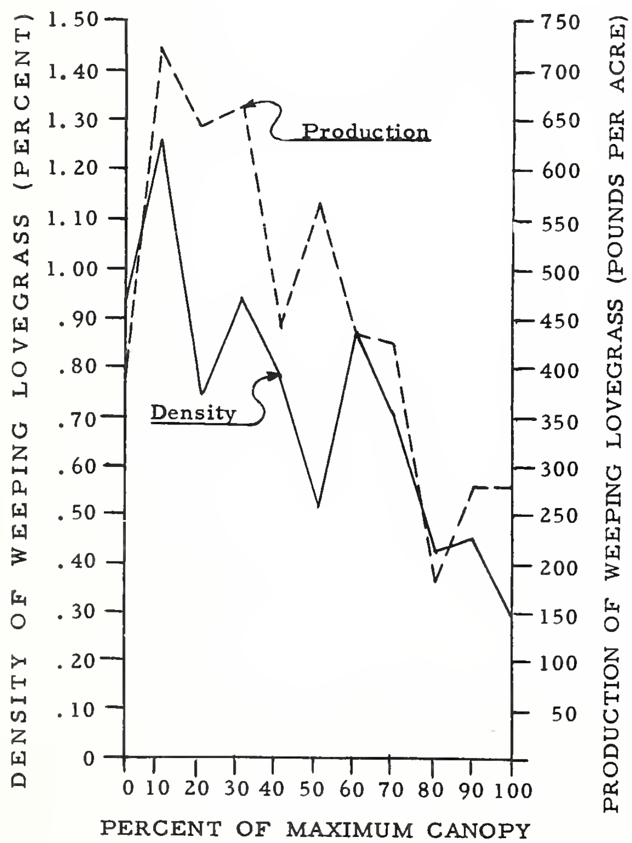


Figure R-3. --Relation between density of shrub live oak and density and production of weeping lovegrass.

except shrub live oak were killed on a series of small plots located near Globe, Arizona, and the crown density of the oaks was altered to give densities at 10-percent intervals from none to 100 percent of the maximum density of shrubs on the study area. Shrubs were poisoned with a basal spray of 2, 4-D and 2, 4, 5-T in diesel oil. Production of weeping lovegrass, after 1 year, ranged from 725 pounds per acre under 10-percent shrub density to 175 pounds at 80-percent shrub density.

Individually burning small junipers cheaper than bulldozing

Burning individual trees was found to be from 18 to 46 percent cheaper than bulldozing as a juniper-control measure when trees were mostly less than 12 feet high or fewer than 50 trees per acre of any size. In the costs shown in table R-2, burning averaged $1.12 to $1.45 per hour for the vehicle and trailer to haul the propane tank, $1 to $1.25 per hour for labor used in burning, and 16 cents per gallon for propane. Costs of bulldozing averaged $12 per operating hour for the bulldozer and operator. No appreciable costs for fire control in the burning operation were assumed. None would be needed if there were little or no wind, or little fuel between the trees. Winds greater than 12 miles per hour blow the propane flame away from the tree and kill is more difficult to obtain.

Table R-2. --Costs for individual tree burning and bulldozing for various types of juniper stands in Arizona

Tree size and stand density	Cost of juniper control	
	Burning	Bulldozing
	Dollars	Dollars
Predominantly small trees		
50 trees per acre	1.97	3.67
100 trees per acre	3.61	5.73
150 trees per acre	5.18	7.52
Predominantly large trees		
50 trees per acre	4.14	5.07
100 trees per acre	7.94	8.53
150 trees per acre	11.68	11.72

Bulldozing and burning with propane torches are both currently used to control scattered, small junipers. Both methods have given kills of 90 to 95 percent. With a bulldozer, each tree is tipped over by pushing it with the dozer blade or with a supplemental pusher bar attached to the dozer blade. In the same forward motion of the tractor the tree is pushed and lifted out of the ground with the dozer blade. Burning is limited to Utah juniper (Juniperus osteosperma) and one-seed juniper (J. monosperma). Alligator juniper (J. deppeana) will sprout prolifically unless the stump is removed. The crown of each tree is burned with a blast of flame lasting 1 to 60 seconds, or about 1-1/2 to 2-1/2 seconds per foot of tree height.

These cost studies were made cooperatively with the Farm Economics Research Division, U. S. Agricultural Research Service.

Burning slash following juniper cabling reduced remaining live trees

Burning of slash following cabling reduced the crown intercept of one-seed juniper that remained after the cabling by about 85 percent. Perennial grasses were temporarily reduced, but 4 years after burning no significant differences in either density or production were observed between the unburned check plots and any of the burning treatments.

Burning grass reduced number of small invading juniper trees

Three control burns on the Coconino National Forest in January, March, and April 1956, when air temperatures were 55° to 75° F. and winds were 8 to 12 miles per hour, reduced the number of small trees of one-seed juniper. Burning when winds were gentle killed 50 percent or more of the trees 3 feet or less in height, but killed fewer taller trees. Windblown debris under the larger trees was not ignited. Burning when winds were stronger ignited the windblown debris under the larger trees and killed more than half of the trees up to 12 feet high. Stands of black grama (Bouteloua eriopoda) and galleta (Hilaria jamesii) carried the fires. Burning had no significant effect on either grass species when measured 3 years later. This is in contrast with experimental burns conducted on the Santa Rita Experimental Range that resulted in high mortality of black grama. The Santa Rita Experimental Range burns were made in June just preceding summer growth.

Root growth retarded by grazing

Root production of plants growing in grassland openings of ponderosa pine-bunchgrass ranges was lowered by grazing from June through October; reduction was proportional to grazing intensity. Figure R-4 compares root systems of ungrazed plants and heavily grazed plants. Roots of ungrazed mountain muhly (Muhlenbergia montana) penetrated the third foot readily, while most roots of plants taken from a heavily grazed area stopped in the second foot. Ungrazed plants had more roots in the second and third foot of soil than did heavily grazed plants. These relationships are being determined in cooperation with Colorado State University, at Manitou Experimental Forest in Colorado.

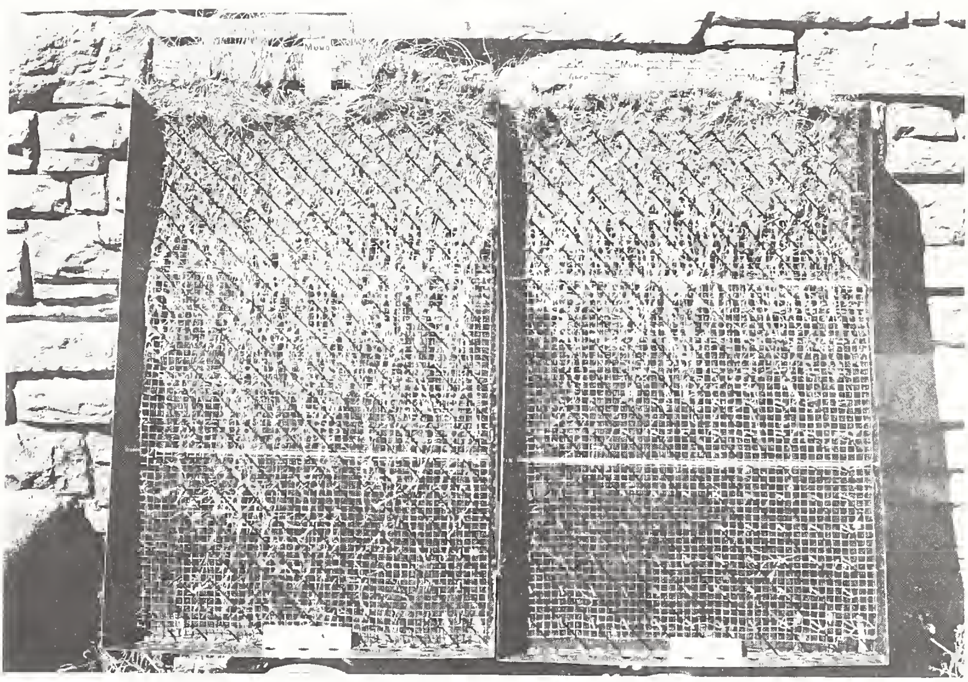


Figure R-4. --Root systems of plants from grassland parks of pine-bunchgrass ranges as exposed by the pin-board method. Plants on left pin-board represent no grazing and those on the right, heavy grazing. Species designated are: Mumo, mountain muhly; POT, cinquefoil; Arfr, fringed sagebrush. The horizontal white lines are spaced at 1-foot intervals to indicate soil depths; the screen wire is 1/2-inch mesh.

Soil moisture and grass growth were not improved by accumulating snow

Forage production and soil moisture of grassland openings on the Medicine Bow National Forest in southern Wyoming were not materially increased by accumulating snow. These areas typically are kept free of snow by high prevailing winds and are low in forage production. An average of 40 inches of snow with 15.7 inches of water was accumulated behind snow fences by March 1958 on an area near Pole Mountain. This did not materially increase soil moisture over that of the check area on which there was no snow accumulation. Somewhat similar results were obtained at another area in the Snowy Range.

Late-lying snow caused 5 weeks' delay in start of vegetative growth compared with the snow-free areas. Maximum height growth of the major grasses was not affected on one area and was increased only a half inch on the other by the additional snow. Herbage production was decreased on one area and increased slightly on the other.

Open-grown and shade-grown Kentucky bluegrass differ in carbohydrate content

Kentucky bluegrass (*Poa pratensis*) growing in open grassland was significantly higher in carbohydrates (nitrogen-free extract or NFE) and lower in crude fiber than in plants growing under a coniferous tree canopy in the Black Hills (fig. R-5). This was determined from analyses of 1958 growth in cooperation with the South Dakota Agricultural Experiment Station. Similar analyses of other grasses showed much the same trends. These differences may partially explain the heavier grazing of grasses in the openings than under ponderosa pine.

Crude protein, calcium, and phosphorus content were not significantly different between open- and shade-grown plants of Kentucky bluegrass. Average crude protein was 15.2 percent in early June, then dropped to about 9 percent by July 1, and remained between 8 and 10 percent through mid-October. Phosphorus declined from an average of 0.35 percent in early June to 0.16 percent in mid-October. Calcium fluctuated irregularly throughout the season; in early June it was 0.33 percent and in mid-October 0.29 percent.

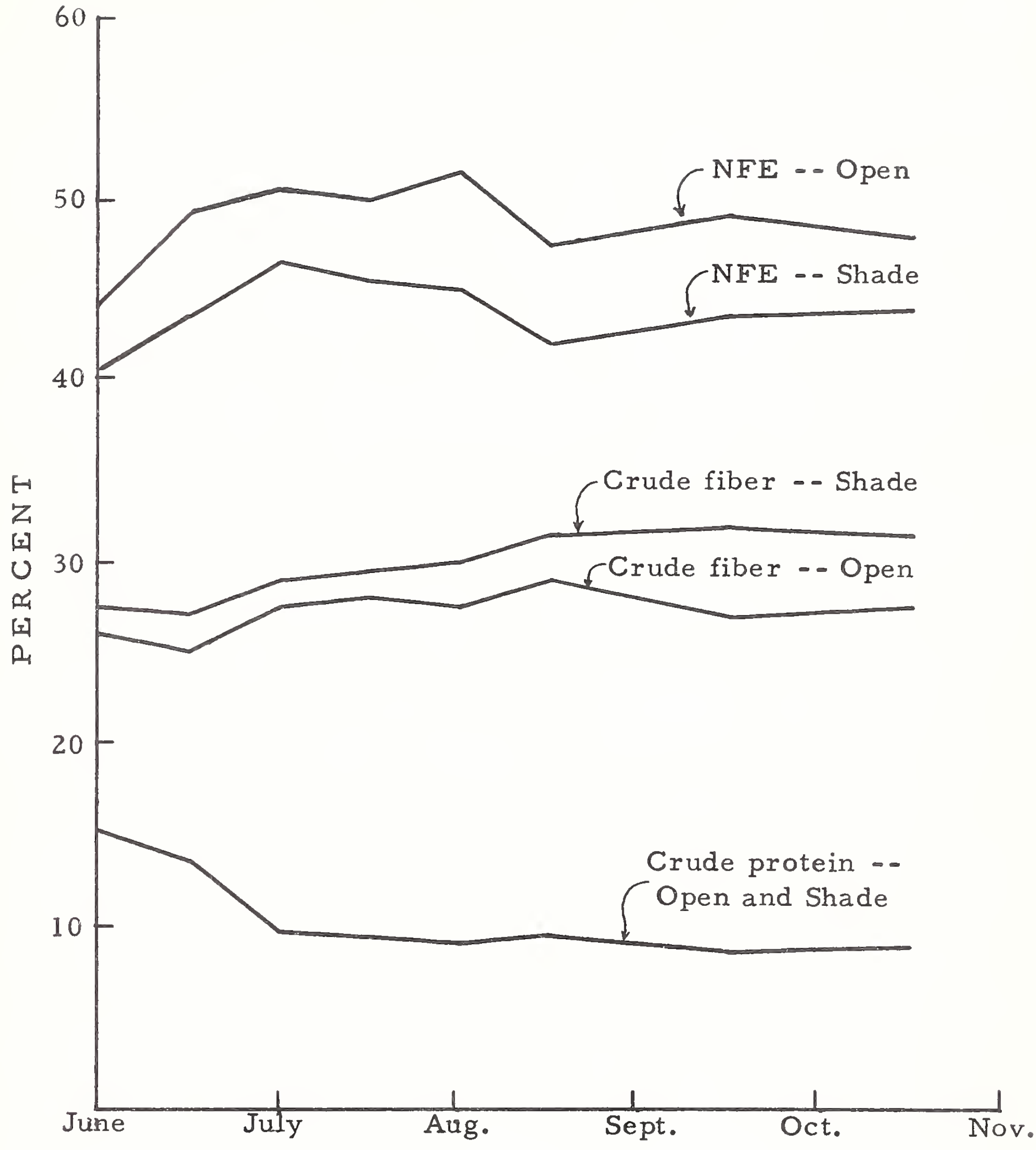


Figure R-5. --Seasonal changes in nitrogen-free extract (NFE), crude fiber, and crude protein content of open-grown and shade-grown Kentucky bluegrass, Black Hills, South Dakota.

Bitterbrush plantings look good in the Black Hills

Based on seedling emergence and survival, bitterbrush (*Purshia tridentata*) has been superior in experimental plantings over five native browse species of the Black Hills. At two deer winter-range sites chokecherry (*Prunus virginiana*), pin cherry *P. pensylvanica*), mountainmahogany (*Cercocarpus montanus*), snowbrush ceanothus (*Ceanothus velutinus*), common juniper (*Juniperus communis*), and bitterbrush were planted in October 1957 in cooperation with the South Dakota Department of Game, Fish, and Parks. Average emergence of bitterbrush was 36.5 percent. By October 1958 the survival of emerged seedlings averaged about one-third. Chokecherry, followed by mountain-mahogany, was next highest in number of seedlings that survived to October 1958.

Greenhouse-grown seedlings of mountainmahogany, bitter-brush, and snowbrush ceanothus, planted in paper pots, had field survival of over 85 percent for the mountainmahogany and bitter-brush, but only 42 percent for the ceanothus. Nursery-grown stock of Saskatoon serviceberry (*Amelanchier alnifolia*) and chokecherry had field survival of 100 and 92 percent, respectively; whereas nursery stock of common juniper did not survive at one study area and only two plants survived at the other.

MOUNTAIN GRASSLAND RANGES

Production of Idaho fescue is inversely related to utilization

Average changes in herbage production of Idaho fescue (*Festuca idahoensis*) from 1951 to 1956 in experimental pastures on the Bighorn National Forest, Wyoming, was associated with intensity of utilization by cattle. The relationships for different soil types are shown in figure R-6. The correlation coefficients of the data indicate that the relationships found so far are not strong. The coefficients are as follows:

Soils derived from sedimentary rocks	0.546
Soils derived from granite	.511

The percent utilization below which production increased and above which production decreased, on the average, was 43 percent on soils derived from sedimentary rocks, 48 percent on soils derived from granite, and 46 percent for all soils combined. Presumably these amounts would approximate maximum average utilization of Idaho fescue allowable over a period of years for range maintenance on ranges of the type under study.

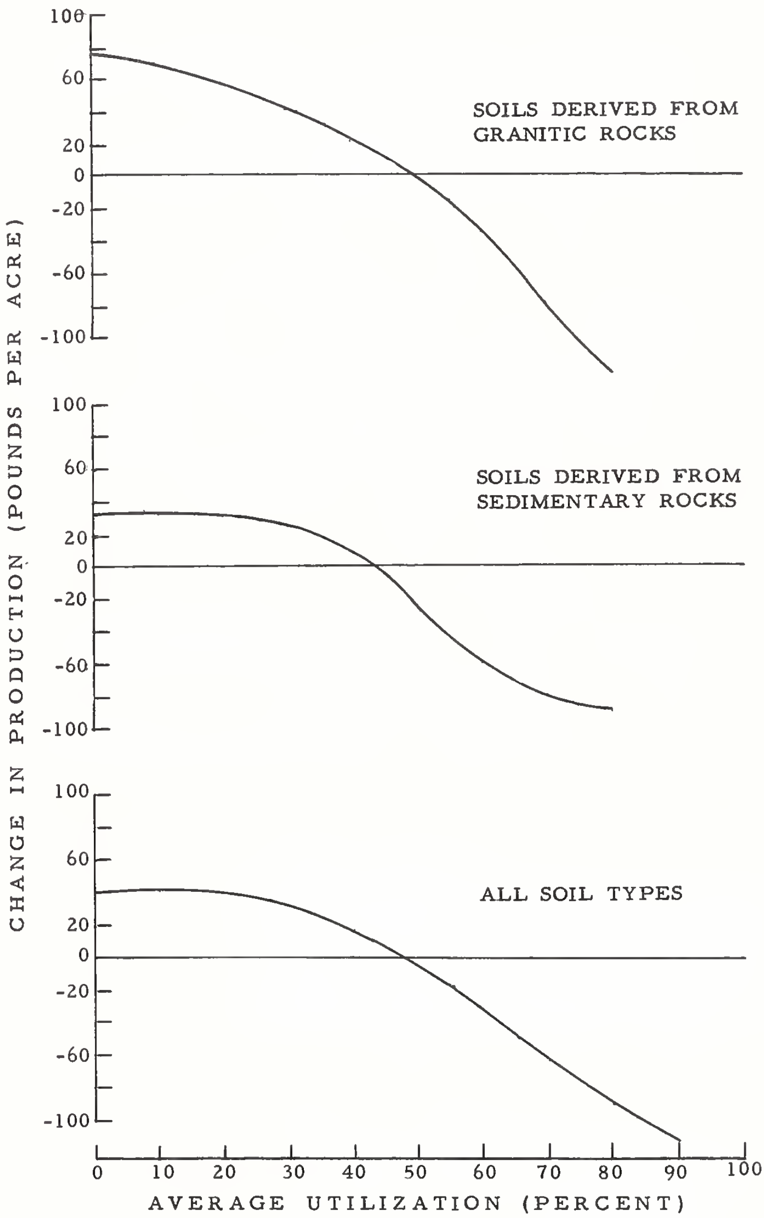


Figure R-6. --Change in herbage production of Idaho fescue with utilization, 1951-56, Bighorn National Forest, Wyoming.

Cattle forage preference altered on different soils

Based on utilization of experimental areas grazed by cattle in the Big Horn Mountains of Wyoming the five most preferred grasses on three soils were as follows:

Soils derived from granitic rocks

Thickspike wheatgrass (*Agropyron dasystachyum*)
Idaho fescue (*Festuca idahoensis*)
Inland bluegrass (*Poa interior*)
Timber oatgrass (*Danthonia intermedia*)
Big bluegrass (*Poa ampla*)

Soils derived from sedimentary rocks

Pumpelly brome (*Bromus pumpellianus*)
Bearded wheatgrass (*Agropyron subsecundum*)
Big bluegrass (*Poa ampla*)
Slender wheatgrass (*Agropyron trachycaulum*)
Idaho fescue (*Festuca idahoensis*)

Soils derived from alluviums

Pumpelly brome (*Bromus pumpellianus*)
Tufted hairgrass (*Deschampsia caespitosa*)
Big bluegrass (*Poa ampla*)
Slender wheatgrass (*Agropyron trachycaulum*)
Kentucky bluegrass (*Poa pratensis*)

The influence of abundance was not considered, so these species were not necessarily the most important forage species on each soil. However, cattle preference was determined on lightly grazed areas where differences in species preference would be pronounced. Although some species are preferred in all soil groups, there is a difference in the order of preference within the soil groups.

Idaho fescue and big bluegrass were preferred species wherever they occurred. Wheatgrasses were intermediate in preference, while needleleaf sedge (*Carex obtusata*) and prairie Junegrass (*Koeleria cristata*) were least preferred. In general, no changes in preference were observed as the grazing season progressed or as grazing pressure increased.

Preferred species also furnished at least 65 percent of the forage although forbs outyielded grasses and sedges approximately 2 to 1 in total herbage. Average utilization of grasses and sedges was 21 percent compared with 2 percent of forbs.

Pocket gophers successfully excluded from range study areas

A 1-acre plot that almost completely excludes pocket gophers and permits normal cattle grazing has been obtained through a combination of fencing and poisoning at Black Mesa near Crawford, Colorado. Cost was approximately $500 for each 1-acre plot. Fences were constructed of 5/8-inch hardware cloth buried 2 feet in the ground and extending 1 foot above ground (fig. R-7). The fence excludes above-ground drift of gophers in the summer. An area 200 feet wide was poisoned around the exclosures to prevent gopher invasion through snow during the winter. Gophers were found to move a maximum of 200 feet during the overwinter period. Gophers burrow through the snow so that a fence at least 4 feet high is required to exclude them. Such a fence is difficult and expensive to build and maintain where snows are deep and where normal livestock grazing is desired.

The difficulty of excluding pocket gophers at reasonable cost from experimental plots on infested ranges has hampered past research on pocket gopher problems. The method using fencing and poisoning was developed cooperatively with the U. S. Fish and Wildlife Service and Colorado Agricultural Experiment Station.

Figure R-7. -- Construction of a pocket gopher exclosure that permits cattle grazing.

Seeding ranges in northern New Mexico costs $6 to $9 per acre

Cost analyses of land preparation and planting rangelands in north central New Mexico and eroded cropland of northeastern New Mexico is presented in New Mexico Agricultural Experiment Station Bulletin 413, "Cost of Seeding Northern New Mexico Rangelands." The analyses, prepared cooperatively with the New Mexico Agricultural Experiment Station, showed crested wheatgrass (*Agropyron cristatum*) can be seeded on sagebrush-woodland ranges at a cost of $6 to $9 per acre. Chances of success are greatest if seeding is done in late summer and fall. Seedings have resulted in yields of 400 to 1,600 pounds per acre; the lowest yield represents a tenfold increase in grass over sagebrush range in poor condition.

A mixture of native grass species including gramas (*Bouteloua* spp.), sand lovegrass (*Eragrostis trichodes*), bluestems (*Andropogon* spp.), and western wheatgrass (*Agropyron smithii*) is recommended for the high plains of northeastern New Mexico. In this area seeding into a stubble or weed cover in May has been most successful. Yields of 1,000 pounds of air-dry forage per acre are likely. The average cost of seeding eroded cropland was $7.57 per acre.

Woody plants in crested wheatgrass stands were heavily utilized by sheep

Though often grazed to some extent during the winter, especially when snow is on the ground, woody plants such as big sagebrush (*Artemisia tridentata*) and rubber rabbitbrush (*Chrysothamnus nauseosus*) are seldom grazed in the spring by sheep after herbaceous plants begin growth. Yet, at Tank Canyon in north central New Mexico, these and other woody species were heavily utilized. Early in May 1958, pregnant ewes were placed in twelve 5-acre paddocks where they lambed and grazed for 52 days. At the end of the grazing season average utilization of the four principal woody species and crested wheatgrass was as follows:

	Percent
Crested wheatgrass (*Agropyron cristatum*)	63
Silver sagebrush (*Artemisia cana*)	82
Big sagebrush (*A. tridentata*)	80
Rubber rabbitbrush (*Chrysothamnus nauseosus*)	75
Douglas rabbitbrush (*C. viscidiflorus*)	63

Utilization of woody species was directly proportional to the intensity of use of crested wheatgrass (fig. R-8). The comparatively heavy use of shrubs probably resulted because they were relatively sparse in the experimental areas. The paddocks support mainly crested wheatgrass, with only scattered woody plants. Also, weed growth in 1958 was sparse and the ewes may have been forced to graze shrubby species as an alternate source of forage.

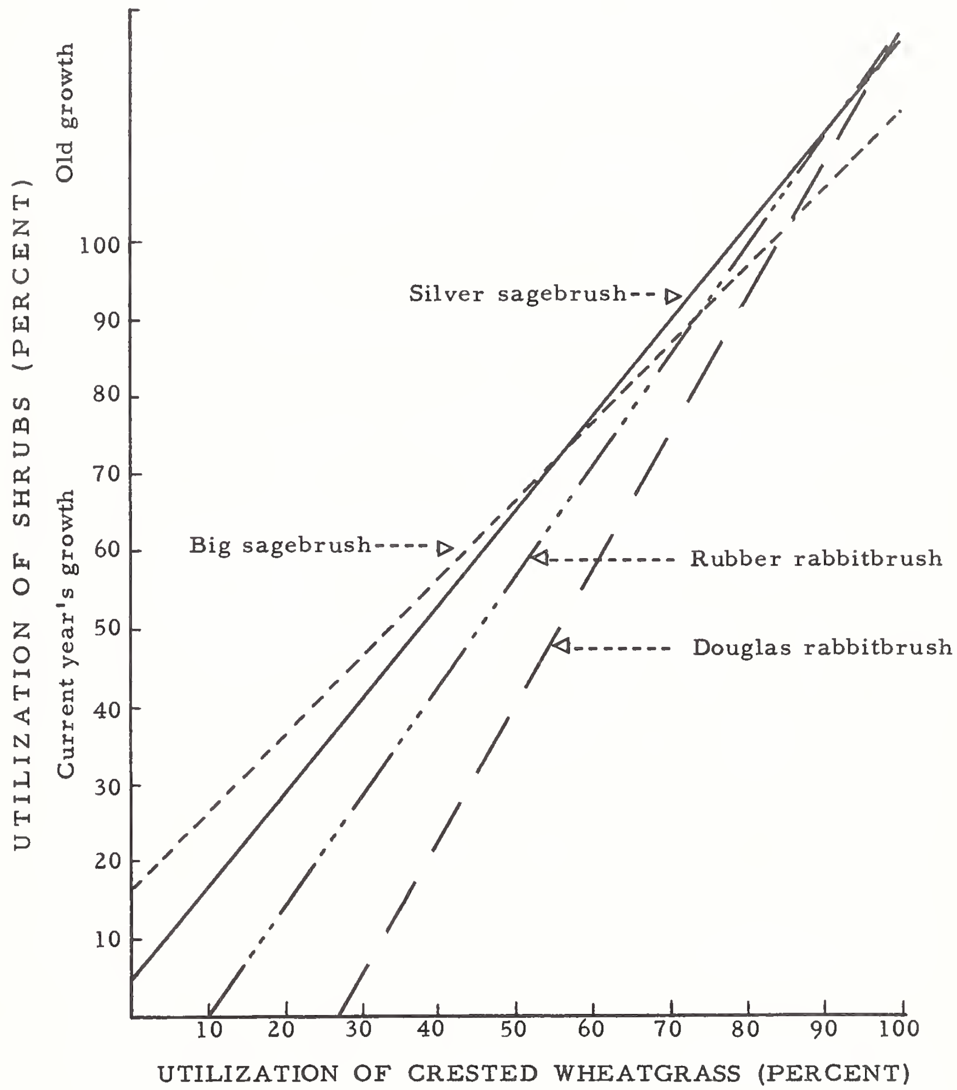


Figure R-8. --Relation between utilization of four shrubs and crested wheatgrass by ewes during lambing. Tank Canyon, New Mexico, 1958.

Big sagebrush increasing in crested wheatgrass stands

Reestablishment of big sagebrush is potentially a serious problem on seeded range in northern New Mexico. Sagebrush plants that survived the seeding operation in 1947 are increasing in size, and many young plants are becoming established in crested wheatgrass stands on Cebolla Mesa. From 1954 to 1958 crown areas of sagebrush increased under all grazing treatments, but the increase was almost twice as great under heavy grazing as under moderate and light grazing. The number of new sagebrush plants was also greatest under heaviest grazing as shown in the following tabulation:

Grazing treatment	Average number of young sagebrush plants per acre
Lightest grazed	280
Medium grazed	560
Heaviest grazed	890

Crested wheatgrass more erect with better moisture and lighter grazing

Among three sites in northern New Mexico, crested wheatgrass had a perpendicular growth form where precipitation was highest (Tank Canyon) in contrast to a definitely spreading form at the driest site (Cebolla Mesa). At No Agua, the intermediate site, plants had an intermediate amount of aerial spread. Differences in the growth form are shown by the various ratios between crown diameter (foliage projection), basal diameter, and leaf-height measurements on plants in lightly grazed areas:

Ratio	Cebolla Mesa	No Agua	Tank Canyon
$\frac{\text{Crown diameter}}{\text{Basal diameter}}$	4.196	2.822	2.546
$\frac{\text{Crown diameter}}{\text{Leaf height}}$	.702	.556	.555
$\frac{\text{Basal diameter}}{\text{Leaf height}}$	.167	.197	.218

Plant height also varies by site as shown by the following measurements of leaf and culm length:

Site	Annual precipitation (Inches)	Average culm length (Inches)	Average leaf length (Inches)
Cebolla Mesa	12.5	10.31	8.34
No Agua	13.3	12.77	9.90
Tank Canyon	16.5	20.18	13.82

Crested wheatgrass changes from an erect or perpendicular growth form to a more spreading or prostrate form under heavy grazing. Plants on the moist site that had undergone comparatively heavy grazing closely resembled plants on the drier sites that had been less heavily grazed; whereas plants on moist sites that had been rather lightly grazed were more erect.

Utilization of crested wheatgrass can be estimated by counting grazed plants

The "grazed-plant" method shows promise for judging spring utilization of crested wheatgrass by cattle in northern New Mexico. In this method, counts of grazed plants are expressed as percent of the total number of plants observed and compared to average utilization by weight. From 1952 to 1957 the method has given much the same relationship at the Cebolla Mesa and No Agua experimental areas (fig. R-9).

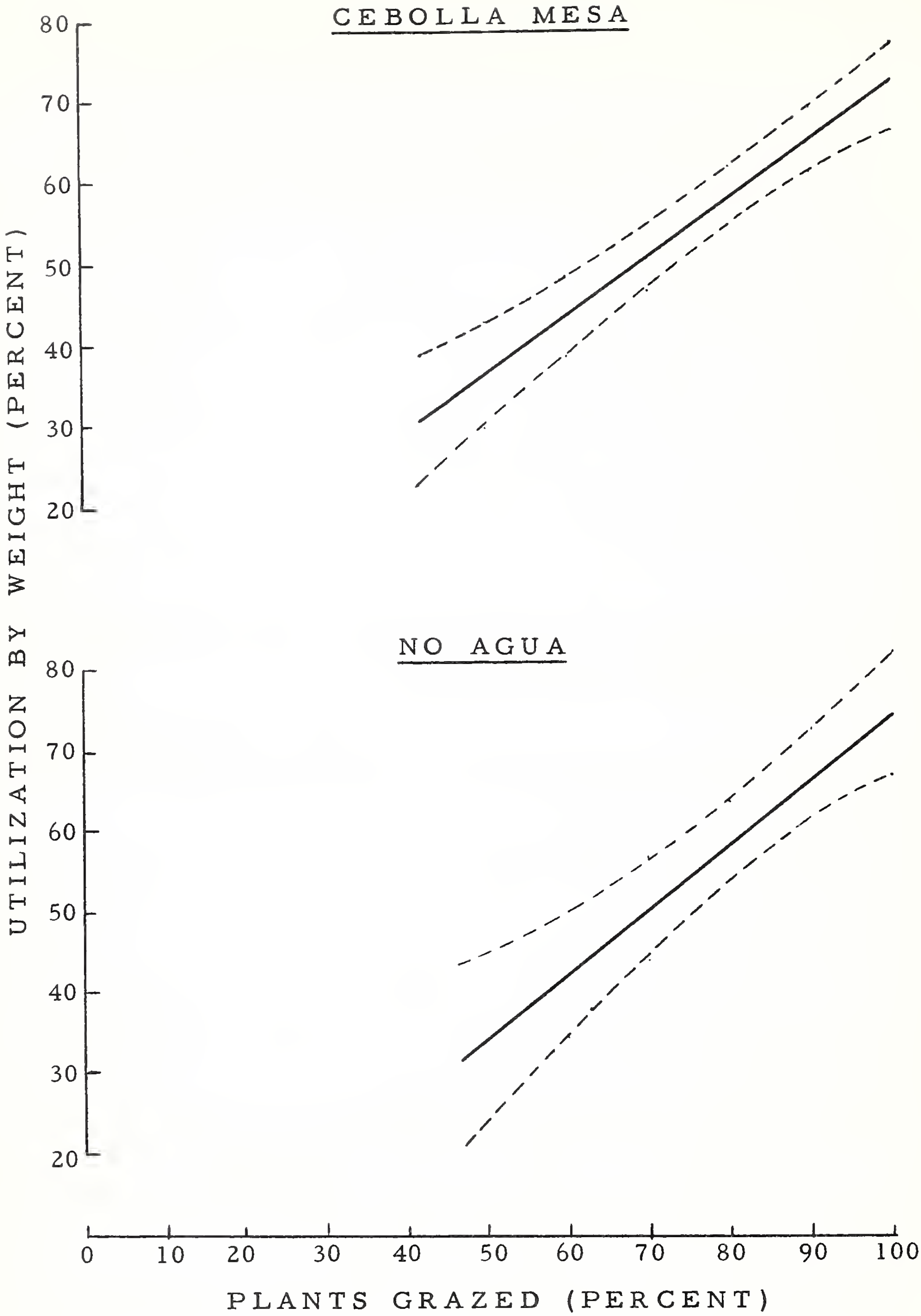


Figure R-9. --Relationship between percent of plants grazed and utilization by weight of crested wheatgrass grazed by cattle: Cebolla Mesa, 1952 through 1957, and No Agua, 1955 through 1957. Confidence limits at the 0.05 probability level are shown by dashed lines.

FOREST MANAGEMENT RESEARCH

Forest management research develops information needed to manage properly the forests in the central and southern Rocky Mountains and for tree plantings in the Great Plains.

Highlights of research in forest management for the year follow.

Moderate to light windfall followed strip clear cutting of spruce-fir

Windfall losses studied in Colorado on sale areas where Engelmann spruce-subalpine fir had been clear cut averaged 1 to 7 trees and 84 to 1,079 board-feet for each 10 chains of cutting-unit boundary. Most of the windthrown trees were felled by the prevailing westerly and southwesterly winds. More than two-thirds fell in the north, northeast, east, and southeast quadrants. No consistent relationship was apparent between amount of windthrow and position on the slope, steepness of slope, or the occurrence of defect. Losses diminished with time since cutting; more trees blew down in the first 3 years after cutting than in subsequent years.

Thinning increased growth of dense young lodgepole pine in the central Rocky Mountains

Increases in diameter 21 to 31 years after thinning averaged 20 to 425 percent greater in thinned than in unthinned stands of

lodgepole pine. Total diameter growth of residual trees in inches (Y) was found to depend primarily on initial diameter in inches (X_1) and growing space per tree in square feet (X_2), as expressed by the regression equation

$$Y = 1.7209 + 0.6303X_1 + 0.0158X_2$$

The correlation coefficient = 0.9705;
standard error of estimate = $\pm$ 0.434 inch.

Diameter growth of individual trees was greatest at the lowest density tested (200 stems per acre).

Thinning usually increased net growth of basal area. Exceptions were the heaviest thinnings in two of the younger stands and all thinning in a 35-year-old stand that was growing well in an unthinned condition (table F-1). Basal-area growth after thinning was generally best on the more heavily thinned plots in the older and larger stands and on the more lightly thinned plots in the younger stands. Total growth of basal area in square feet (Y) was mostly accounted for by reserve basal area in square feet (X_1), age in years at time of thinning (X_2), and growing space per tree in square feet (X_3). The regression equation expressing the relationship,

$$Y = 72.1373 + 0.9178X_1 - 0.4902X_2 - 0.0421X_3$$

has a correlation coefficient of 0.9728;
standard error of estimate of $\pm$ 10.32 square feet per acre.

There is little advantage in reserving more than 600 trees per acre in stands that average 1.0 and 2.0 inches d.b.h. Total growth approaches a maximum at that density and subsequent mortality increases rapidly at greater densities. When initial diameters of residual trees averaged 5.0 inches, total growth was greatest at 300 stems per acre. Growth at all densities decreased slightly with an increase in the age of the trees.

Table F-1. --Effects of thinning young lodgepole pine in the central Rocky Mountains
(All data on a per-acre basis)

Location	Date established	Average age when thinned	Spacing	Trees after thinning	Trees alive in 1955	Average annual growth after thinning: Diameter	Basal area
		Years	Feet	No.	No.	Inches	Sq. ft.
Meadow Creek	1924	65	Unthinned	2,244	1,480	0.032	0.51
(Arapaho	1924	65	5.2 x 5.2	1,608	1,324	.038	.82
National	1924	65	8.4 x 8.4	620	576	.045	1.16
Forest)	1933	75	11.0 x 11.0	360	336	.074	1.17
Clear Creek -	1928	35	Unthinned	5,334	4,818	.027	2.51
Sourdough Divide	1928	35	8.4 x 8.4	615	558	.097	2.06
(Bighorn	1928	35	9.9 x 9.9	449	407	.101	1.58
National Forest)							
Long Creek	1934	78	Unthinned	2,230	1,651	.034	.39
(Shoshone	1934	78	11.0 x 11.0	361	340	.083	1.73
National Forest)	1934	78	11.3 x 11.3	340	323	.078	1.58
Chimney Park	1933	35	Unthinned	20,980	10,792	.025	1.70
(Medicine Bow	1933	35	5.0 x 5.0	1,752	1,392	.083	2.51
National	1933	35	7.2 x 7.2	828	640	.116	1.96
Forest)	1933	35	9.7 x 9.7	464	404	.132	1.70
Chimney Park	1933	38	Unthinned	8,880	6,120	.030	2.16
(Medicine Bow	1933	38	7.4 x 7.4	802	782	.093	2.88
National	1933	38	9.8 x 9.8	450	438	.118	2.37
Forest)	1933	38	12.5 x 12.5	280	272	.140	1.91
Fox Park	1933	44	Unthinned	2,018	1,818	.033	1.98
(Medicine Bow	1933	44	9.9 x 9.9	444	432	.090	2.15
National	1933	44	12.2 x 12.2	292	278	.105	1.95
Forest)	1933	44	14.6 x 14.6	204	198	.108	1.48

Lodgepole pine survived better than Engelmann spruce when planted in area of beetle-killed spruce

Lodgepole pine survived better than Engelmann spruce in experimental planting on the White River Plateau. Only 24 percent of the pines had died by the end of the second summer; 41 percent of the spruces had died. The spruce survived well through the first summer, but overwinter losses were heavy. Losses were moderate the second summer. Pine losses were uniform for the three seasons (fig. F-1).

Watering had no apparent influence on survival of lodgepole pine -- 90 percent of the watered and 87 percent of the unwatered still survived at the end of the second summer. Although survival of spruce was improved significantly by watering (table F-2), vigor of both the watered and unwatered seedlings was poor. The vigor of surviving pines was good.

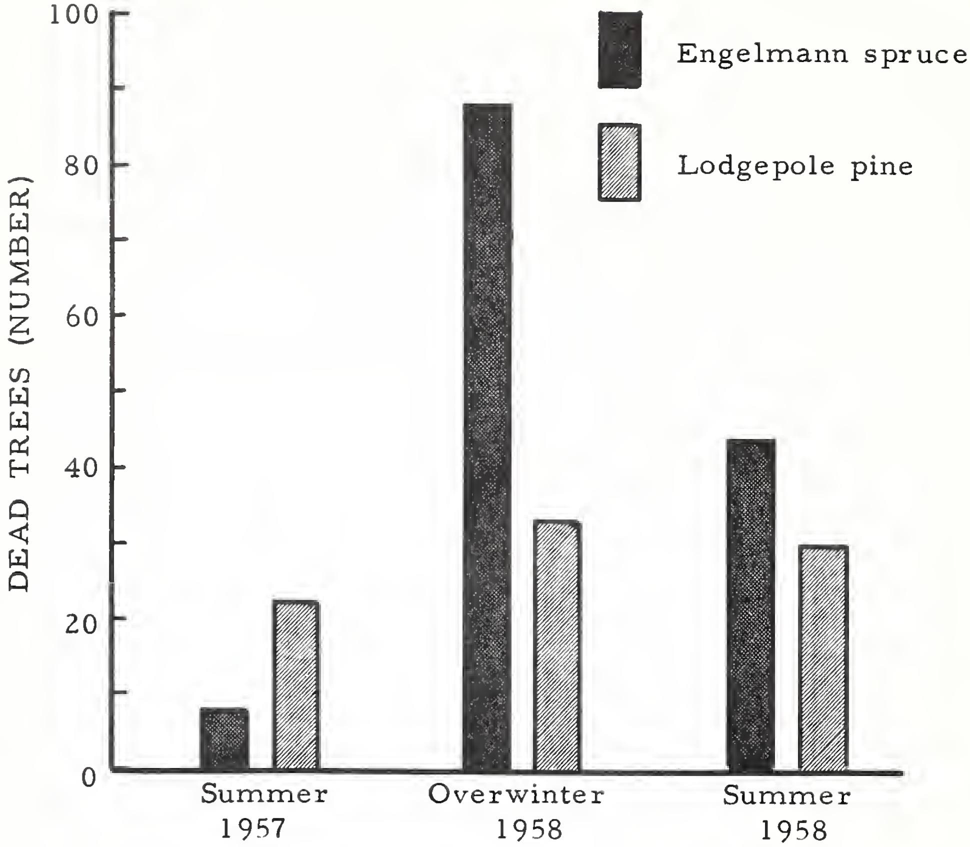


Figure F-1. --Seasonal mortality of nursery stock where no cultural treatments were applied (340 trees of each species planted).

Table F-2. --Seasonal mortality of watered and unwatered nursery stock

Species and treatment	Trees planted	Mortality			
		Summer 1957	Winter 1957-58	Summer 1958	Total
	No.	Percent			
Lodgepole pine					
Watered	100	3	5	2	10
Not watered	100	1	6	6	13
Engelmann spruce					
Watered	100	0	36	7	43
Not watered	100	0	40	18	58

Shading improved survival of planted Engelmann spruce

Shading with shingles through the summer improved over-winter survival of Engelmann spruce that was planted in the spring of 1957. Only 1 out of 50 trees that had been shaded through the summer of 1957 died during the following winter whereas 21 trees that had not been shaded died. By the end of the summer of 1958 survival was 80 percent for shaded but only 32 percent for trees that were unshaded (table F-3). The shaded spruces were more vigorous looking than the unshaded (fig. F-2).

Table F-3. --Seasonal mortality of shaded and unshaded nursery stock

Species and treatment	Trees planted	Mortality			
		Summer 1957	Winter 1957-58	Summer 1958	Total
	No.	Percent			
Lodgepole pine					
Shaded	50	2	18	8	28
Not shaded	50	12	8	8	28
Engelmann spruce					
Shaded	50	2	2	16	20
Not shaded	50	4	42	22	68

Engelmann spruce is highly shade tolerant in its youth. It is possible that it is not highly sun tolerant. The sun's rays are intense at the 10,000-foot elevation of the planting site. It appears from these 1-year results that full exposure to the sun reduces the capacity of the spruces to survive over the winter.

Shading may have helped first-year survival of lodgepole pine, but subsequent losses erased the advantage. By the end of the summer of 1958 shaded and unshaded trees survived in equal numbers (table F-3).

Figure F-2.--Shading by shingles improved survival of Engelmann spruce seedlings.

<u>Shading and mulching improved survival of seeded lodgepole pine</u>

Shading, mulching, and shading and mulching improved survival of lodgepole pine. The shade-and-mulch treatment was best. However, losses have been heavy and are continuing (table F-4).

Table F-4. --Germination and survival of lodgepole pine in 200 seed spots for each treatment, 15 seeds per spot

Treatment	Seedlings emerged	Seedlings surviving October 1957	Seedlings surviving July 1958	Spots stocked September 1958	
	No.	No.	No.	No.	Percent
Shade	1, 265	714	163	65	32
Mulch	1, 308	623	166	60	30
Shade and mulch	1, 377	813	244	98	49
No treatment	1, 230	493	53	27	14
Total	5, 180	2, 643	626		

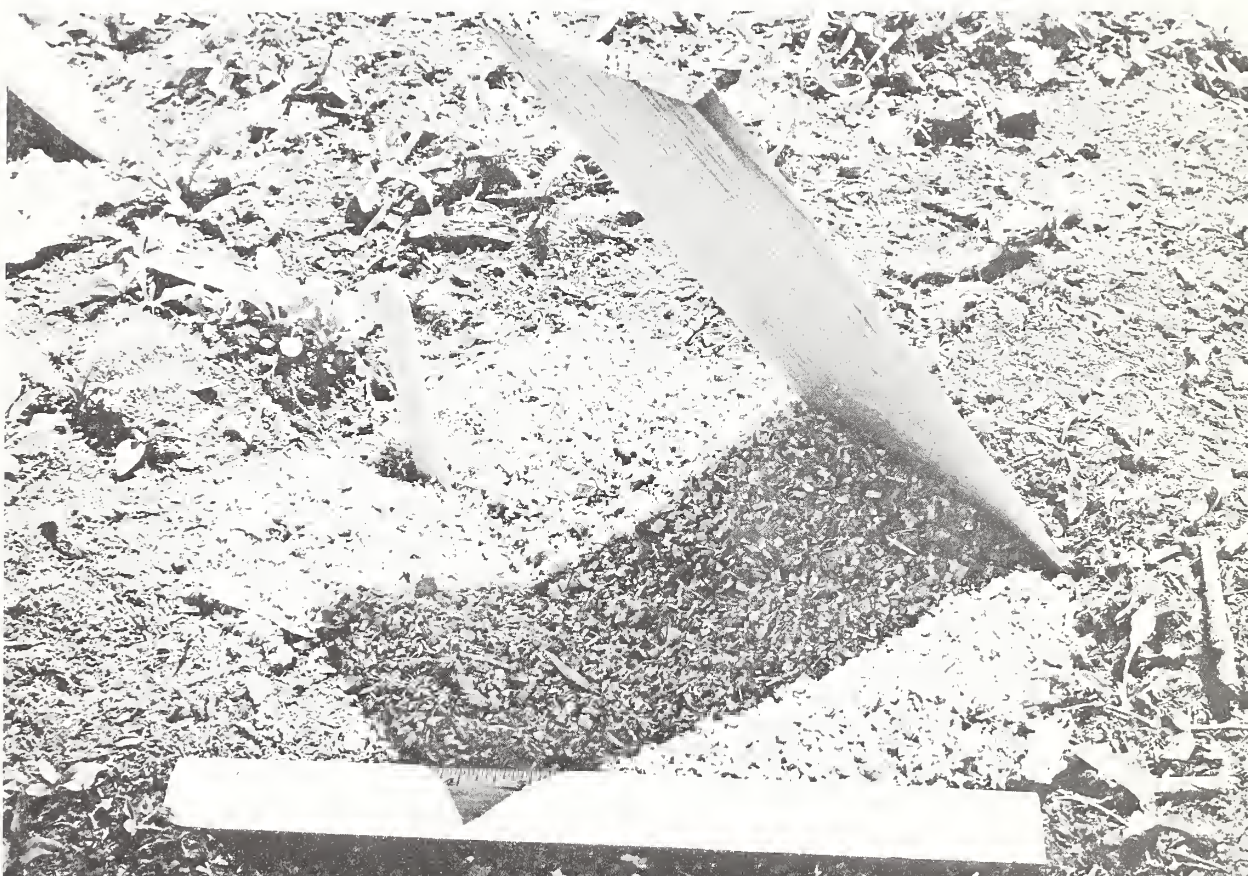


Figure F-3. --Combined shade-and-mulch treatment applied to lodgepole pine seed spot.

Lifting date, cold storage, and grading may influence survival of coniferous nursery stock

Above-average grades of ponderosa pine, lodgepole pine, and Engelmann spruce survived significantly better than below-average grades when planted immediately after lifting. The above-average grades of ponderosa pine and spruce also survived significantly better when planted at 5,200 feet elevation after 4 to 10 weeks of cold storage. Survival of the 2 grades of lodgepole pine did not differ significantly when planted at 5,200 feet after storage, nor for spruce and lodgepole when planted above 10,000 feet after 6 to 12 weeks of storage.

No significant differences in survival for any of 3 species was found to be associated with 6 different lifting dates that extended from April 6 to May 11, when the planting was done immediately after lifting (fig. F-4). That was surprising as top growth of lodgepole pine started 4 weeks, and of spruce, 2 weeks, before the last lifting.

Changes in survival that could be attributed to lifting date were likewise not statistically significant for trees that were stored before planting. However, lodgepole pine lifted on May 11 and planted at the State nursery near Fort Collins (5,200 feet elevation) following storage, survived much more poorly than earlier liftings, and survival of lodgepole pines planted on the White River Plateau (10,000 feet elevation) declined steadily for each successive week of lifting after growth started. Stored Engelmann spruce that were lifted on the last date also survived poorly.

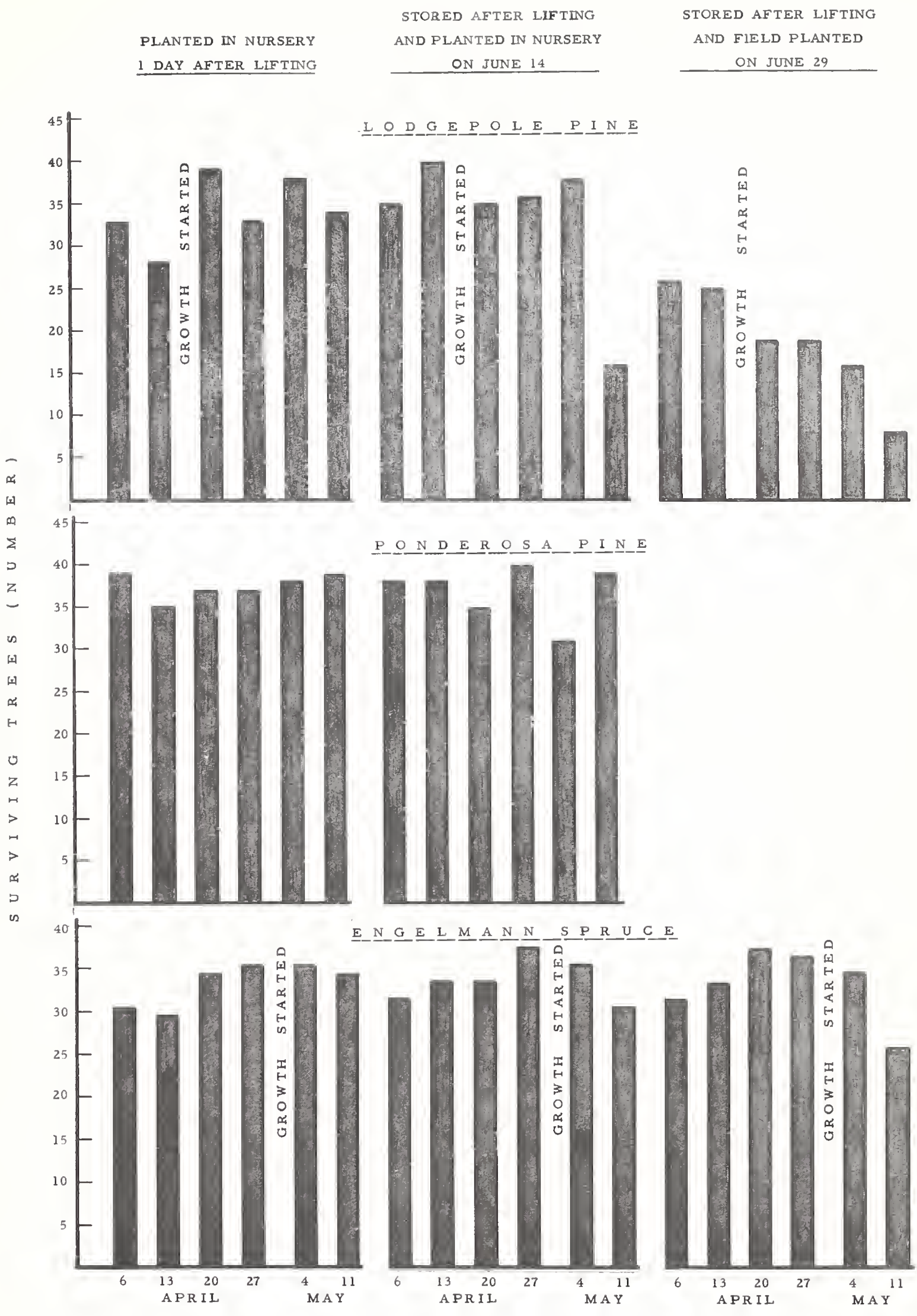


Figure F-4. --Survival of lodgepole pine, ponderosa pine, and Engelmann spruce seedlings following different lifting dates and storage treatments. Basis: 40 trees of each species on each lifting date.

Productivity of forest soils in the Black Hills can be determined from soil depth and topography

The value of Black Hills soils for producing ponderosa pine can be determined from four easily measured factors, namely; (1) soil depth to top of the C horizon, (2) slope position, (3) slope percent, and (4) aspect. Soil depth, ranging from 3 to 57 inches, has the greatest influence on tree growth. Slope position is second in importance, and the only other factor needed in part of the Black Hills.

Site index, average height of the dominant trees of a stand at age 100 years, is the usual way of expressing the productivity of forest soils. Observed site indexes for ponderosa pine in the Black Hills ranged from 36 to 75 feet. Vigorous trees on good sites (site index 60 to 70) average 18 to 20 inches in diameter, breast height, when 160 years old (fig. F-5). The better trees on areas with site indexes of 40 or less average 10 inches d. b. h. at the same age (fig. F-6). Most areas within the commercial forest zone of the Black Hills have site indexes between 50 and 67 feet, with an average of about 55 feet.

Two equations have been developed which express site index in the two major geologic areas of the Black Hills:

In the central Black Hills where the soils are derived from metamorphic and igneous rocks:

$$Y = 1.64660 - 0.10315X_1 - 0.01895X_2 - 0.09042X_3 + 0.13330X_4$$

On soils from the limestone that encircle the central Hills:

$$Y = 1.54200 - 0.11819X_3 + 0.20821X_4$$

In both equations:

Y = common logarithm of site index

X_1 = grade or percent of slope, expressed as a decimal

X_2 = aspect as the sine of the azimuth clockwise from southeast, plus one

X_3 = distance of sampling point up the slope expressed as a decimal of total slope length

X_4 = common logarithm of soil depth in inches to top of the C horizon

Figure F-5. --Ponderosa pine on a good site (site index 67) where the soil is 41 inches deep. The dominant trees, averaging 128 years old and 17.4 inches d.b.h., yield good saw logs.

Figure F-6. --Ponderosa pine on a poor site (site index 36) with only 3 inches of soil. The dominant trees average only 11.7 inches d.b.h. even though they are 189 years old. The best trees are barely acceptable for saw logs.

The usual method of computing site index requires the measurement of tree height and age, and can be used only in fairly well-stocked stands. These two equations, however, can be used to determine site index on burned-over areas, in dense young stands where height growth is retarded, or anywhere else in the commercial forest zone.

Figure F-7. --Dial-gage dendrometer measuring periodic radial growth on Black Hills ponderosa pine.

Thinning improves ponderosa pine diameter growth 2 years after treatment

Thinning Black Hills ponderosa pine will increase diameter growth at breast height 1-1/2 to 2 times in the second year after treatment according to the measurements of radial growth with a dial-gage dendrometer (fig. F-7). Diameter growth of dominant trees on a thinned plot containing 492 trees per acre (9.5- x 9.5-foot spacing) was more than 0.21 inch. By comparison, dominants on an unthinned plot with 2,838 trees per acre (3.9- x 3.9-foot spacing) grew only 0.14 inch in diameter. Diameter growth of codominant trees on the thinned and unthinned plots was 0.18 and 0.10 inch, respectively (fig. F-8).

Diameter growth was found to continue 2 months longer on the thinned plot. Trees on the unthinned plot ceased diameter growth by July 28, whereas trees on the thinned plot continued until September 29 (fig. F-8). Half the diameter growth was made in the first 35 to 40 days for both crown classes and plots. By the time diameter growth had stopped for both crown classes on the unthinned plot, it was 82 percent completed for the thinned dominants and 91 percent completed for the thinned codominants. The rate of growth was slow in late summer.

Thinning had little effect on second-year height growth (fig. F-9). Average total height growth for all trees was 9.3 inches. The duration of height growth for both crown classes in each plot averaged 67 days. There were no significant differences in duration or amount of height growth between dominants and codominants or between plots.

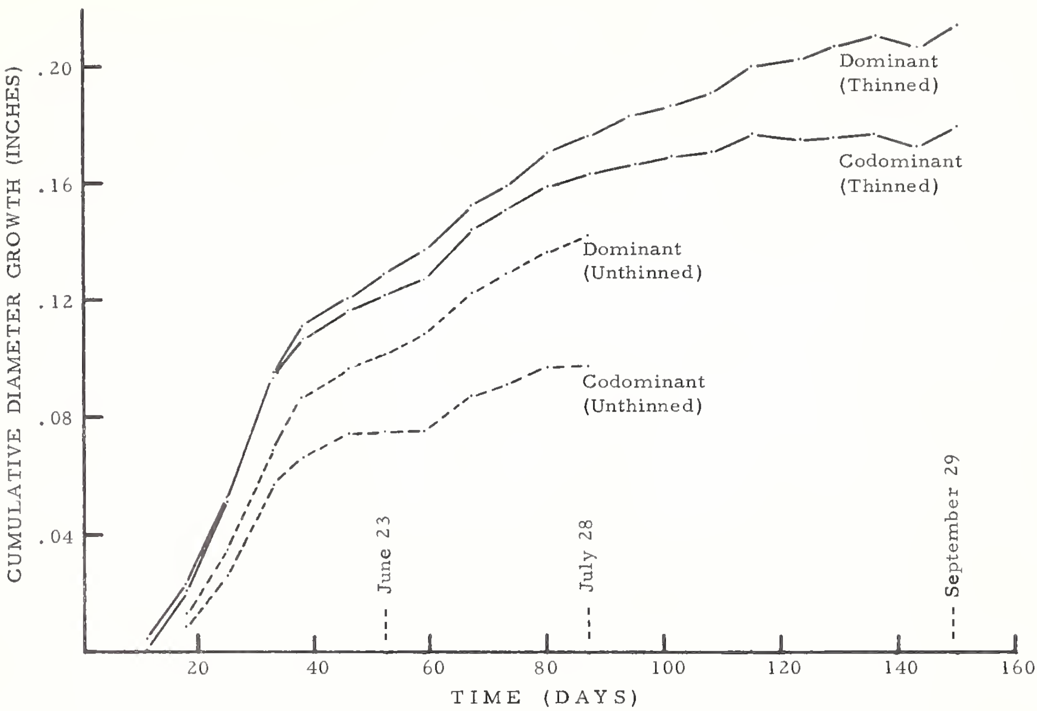


Figure F-8. --1958 cumulative diameter growth by crown class for ponderosa pine poles thinned in 1957 and for those left unthinned.

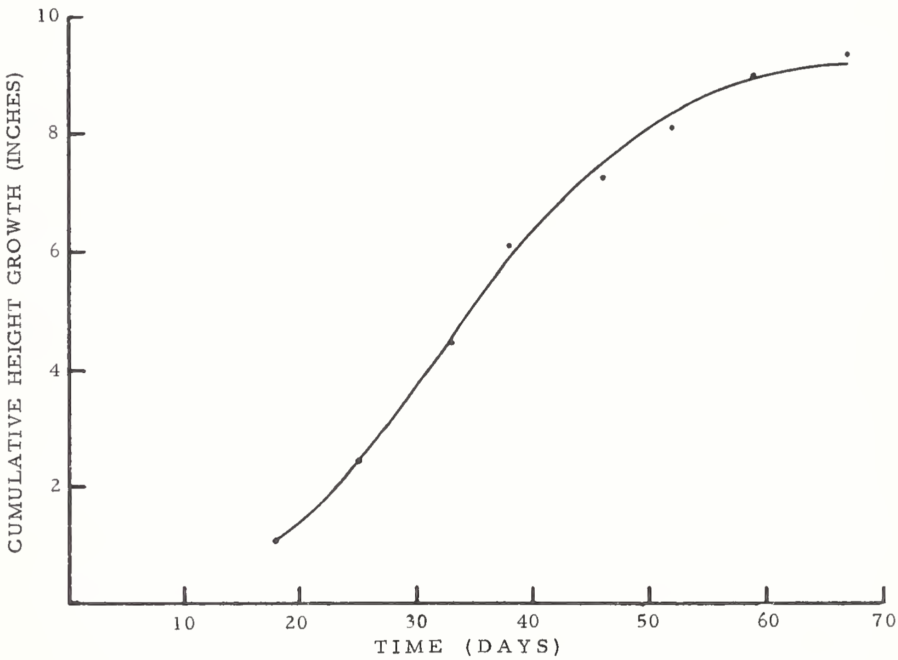


Figure F-9. --1958 average cumulative height growth -- combined results for dominant and codominant ponderosa pine poles on both thinned and unthinned plots.

Figure F-10. -- Glass-faced box used to study root growth of seedlings. The front of the box is plate glass and the remainder is sheet metal. The screens protect seedlings from birds.

Glass-faced boxes prove useful in studying root growth of ponderosa pine seedlings

Tilted, glass-faced boxes have proved valuable for studying root growth of tree seedlings and other plants. At the Fort Valley Experimental Forest in northern Arizona, ponderosa pine seeds were planted about an inch from the glass front in soil-filled boxes set in the ground at a 30-degree angle. The seedling roots grew straight down until they hit the glass, then grew along the inner surface where they were easily visible (fig. F-10). The time that root growth commenced, daily or weekly root elongation, and time that lateral roots began to form were noted.

A disadvantage of the method is that the soil must be disturbed to fill the boxes. To relate root growth in the boxes to the root growth of seedlings in undisturbed soil, ponderosa pine seedlings were grown in undisturbed soil near the glass-faced boxes, washed out of the soil, and compared to the box-grown seedlings. Roots of the outside trees were only 62 percent as long, and the seedlings only 65 percent as heavy, as those grown in the boxes. However, the correlations between box-grown and outside-grown seedlings of the same ages were very high:

$r = 0.984$ for root length, and

$r = 0.945$ for total dry weight of seedlings.

Hence, the box studies can be considered reliable for showing relative growth of seedlings.

Root development of ponderosa pine seedlings is related to germination date

A study of root growth of ponderosa pine seedlings in relation to seed size, planting and germination dates show that seed size did not affect root length; also seedlings that got the earliest start, penetrated the deepest (fig. F-11). Seedlings that germinated by July 22 grew roots nearly three times as long by November 12 as those germinating August 26.

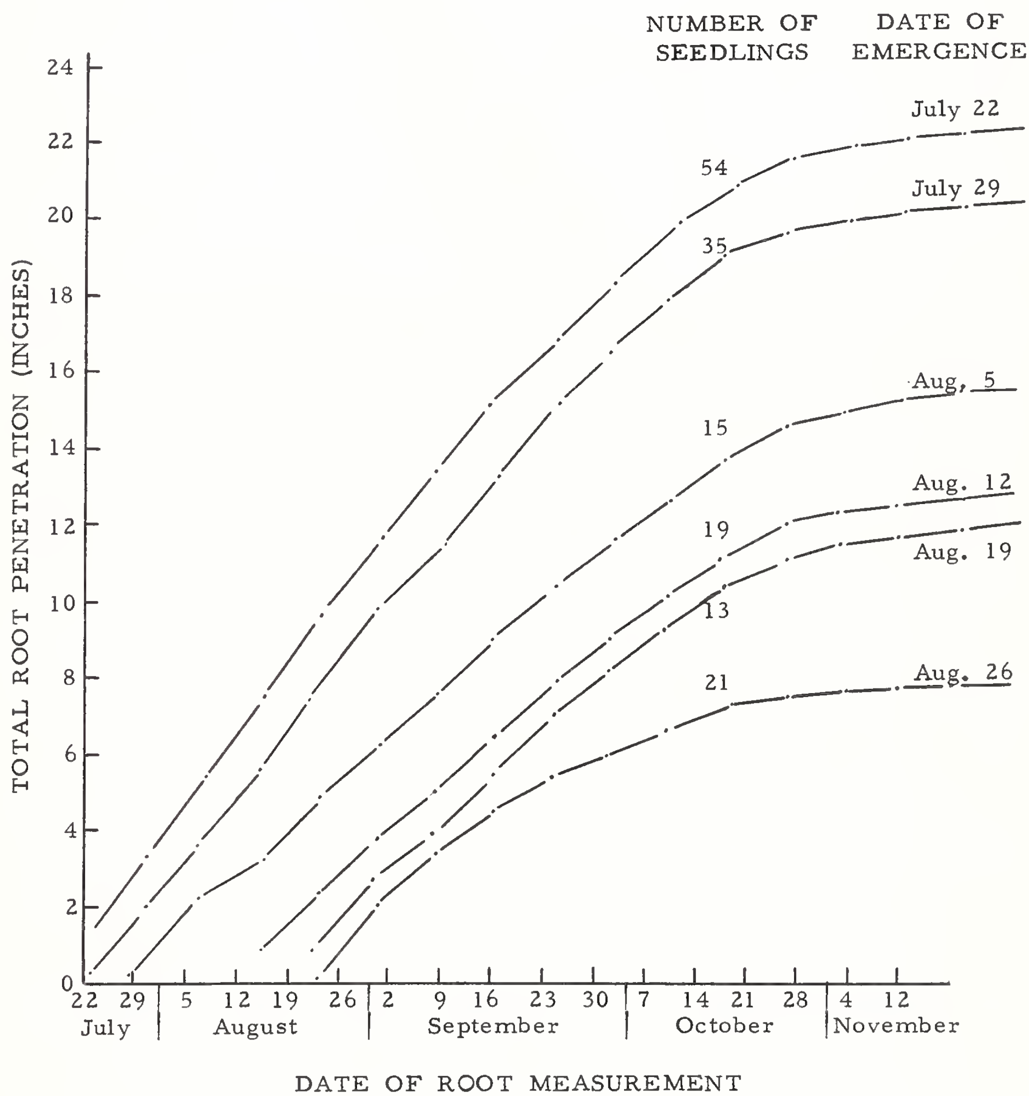


Figure F-11. --Average cumulative root penetration of seedlings germinating at different dates.

Supplemental light increases size of seedlings in nursery

TEST A. -- Supplemental light that extended daylight to 20 and 24 hours of continuous illumination was provided nursery beds that contained ponderosa pine and eastern redcedar seedlings and redcedar transplants (fig. F-12). Treatments lasted from July 15 to October 4, 1957, and from April 1 to September 22, 1958.

Treated trees in all three beds were taller, and grew more in 1958, than the untreated (table F-5). The redcedars made best growth in 1958 and were tallest under continuous light. The ponderosa pines made best growth in 1958 and were tallest under 20 hours of light. In 1957, the first season of supplemental light, the ponderosa pines grew the most under continuous light.

Table F-5. --Height growth of seedlings in nursery beds that received supplemental light for 1-1/2 growing seasons

Treatment	Length of bed segment	Total tree height Nov. 1958	Height increment during 1958 growing season
	Feet	Cm.	Cm.
PONDEROSA PINE SEEDLINGS			
No treatment	53	11.9	7.2
20 hrs. continuous light	12	15.1	10.0
24 hrs. continuous light	11	14.0	8.2
REDCEDAR SEEDLINGS			
No treatment	36	27.1	21.6
20 hrs. continuous light	13	32.1	26.1
24 hrs. continuous light	13	34.0	28.2
REDCEDAR TRANSPLANTS			
No treatment	48	26.3	10.0
20 hrs. continuous light	10	30.8	12.0
24 hrs. continuous light	10	33.7	15.8

Figure F-12. --Seedlings in the nursery grow faster when provided supplemental light at night.

TEST B. --Sections of nursery beds freshly sown with ponderosa and Austrian pine seeds were provided with supplemental light from July 15 to the end of the 1957 growing season and all of the 1958 growing season. Seed came from 5 ponderosa and 2 Austrian pine parent trees. Treatments included 24 hours and 20 hours of continuous light daily, 20 hours with two dark periods daily, and no supplemental light.

All ponderosa pines grew larger under supplemental light than without it (table F-6). Progeny of 3 parent trees made best growth under 24 hours of continuous light. Progeny of 2 others grew better under 20 hours of continuous light, indicating a possible genetic control of response.

Growth of ponderosa was greater under 20 hours' continuous light than under 20 hours of interrupted light.

Austrian pine responded well to supplemental light, but those that received 24 hours' continuous light were so succulent in the fall of 1957 that the tips were killed back during winter. Consequently, total height growth for the 2 seasons was better under 20 hours of light, either continuous or interrupted.

Table F-6. --Average height of seedlings of ponderosa pine and Austrian pine from different seed trees after 1-1/2 growing seasons of supplemental light treatments in nursery plots

No. of parent tree	24 hours' continuous light		20 hours' continuous light		20 hours' interrupted light		No supplemental light	
	Progeny	Height	Progeny	Height	Progeny	Height	Progeny	Height
	No.	Cm.	No.	Cm.	No.	Cm.	No.	Cm.
				PONDEROSA PINE				
5	44	18.2	51	16.4	48	15.0	58	9.8
6	27	14.9	24	14.4	24	11.8	24	8.7
10a	15	12.9	16	14.9	15	11.4	12	8.0
10	14	14.5	23	12.2	16	10.8	23	7.9
8a	15	11.2	21	12.8	16	9.9	22	7.4
	115	15.4	135	14.6	119	12.7	139	8.8
				AUSTRIAN PINE				
2	26	7.6	41	8.6	45	8.9	41	7.8
3	6	7.3	8	8.6	11	7.8	20	5.5
	32	7.6	49	8.6	56	8.7	61	7.1

Basis for the 2-index system for rating forest fire danger

Dangerous burning conditions are a product of drought and current weather in the pine forests of Arizona and New Mexico. The marked droughts of spring and fall dry the large and other slow-drying fuels to low levels. Then dry, hot, windy weather quickly creates critical burning conditions.

A drought index to express effects of cumulative drying and a rate-of-spread index to account for the influence of current weather were therefore made the basis of the 2-index system for rating forest fire danger.

The drought index was derived as follows: An equation was derived expressing the moisture in the upper 12 inches of soil in terms of total winter precipitation, season of year, temperature, and current precipitation. The equation proved quite accurate (fig. F-13). Furthermore, soil moisture estimates by the equation correlated well with the moisture content of logs (fig. F-14).

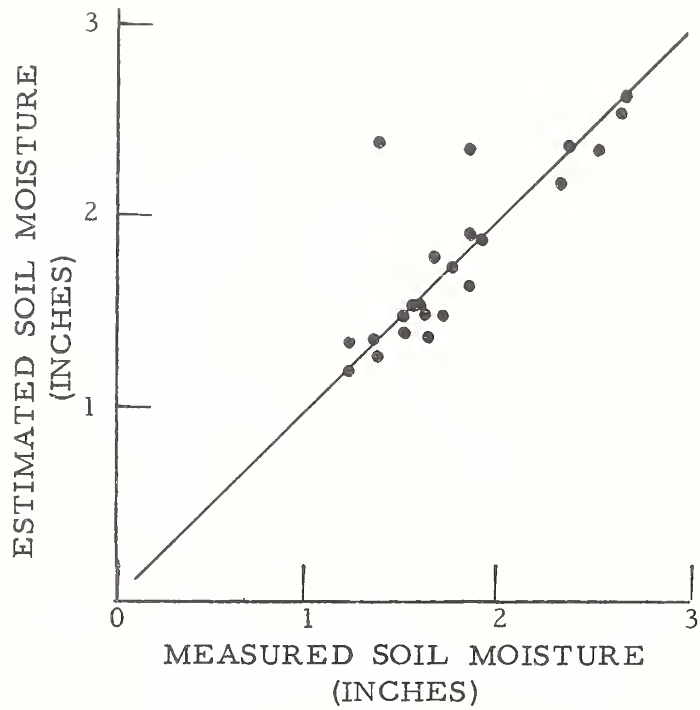


Figure F-13. --Relation of estimated to measured soil moisture in the Manzano Mountains, New Mexico.

The equation is therefore used to compute "drought indexes" from 0 to 100 that are related linearly to log moistures of 55 to 10 percent.

The "rate-of-spread index" was obtained from a regression that expresses the rate-of-spread of small fires in terms of wind velocity, air temperature, and a "litter-moisture factor." The litter-moisture factor was integrated from current temperature, precipitation, and time of year.

The prominent place of air temperature in computing a rate-of-spread index is made possible by the slight day-to-day variations in absolute humidity on days without rain in the Southwest. Changes in both vapor-pressure deficit and relative humidity are therefore largely functions of changes in air temperature. Air temperature can therefore be used as a satisfactory expression of atmospheric dryness and the current moisture content of fire fuels.

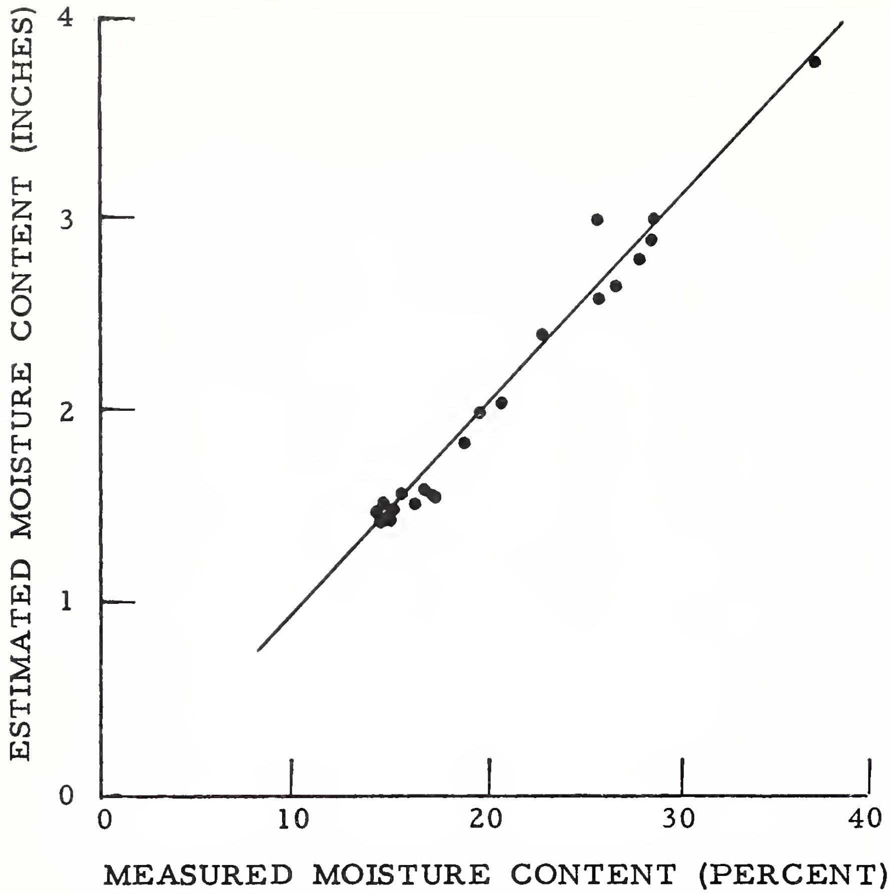


Figure F-14. --Relation of estimated soil moisture to measured moisture content of logs at Priest River, Idaho.

Arizona chaparral difficult to burn

The following was learned from an attempt to burn Arizona chaparral that had been 100 percent smashed, 50 percent smashed, and not smashed with a bulldozer, under noncritical burning conditions in October:

1. Chaparral fire can easily be kept under full control under the noncritical burning conditions present at the time of the test.

2. Considerable pretreatment will be necessary to make chaparral brush burn readily under noncritical conditions.

3. Dead smashed brush burned readily. The volume and continuity of such material was a key factor in getting the fire to spread and cleanup.

FOREST INSECT RESEARCH

FOREST INSECT CONDITIONS IN COLORADO, WYOMING, AND SOUTH DAKOTA

Engelmann spruce beetle increases in Colorado

Spruce beetle (Dendroctonus engelmanni Hopk.) populations gradually built up in cull material in the logged areas (fig. I-1), and in the blowdown at the edges of the uncut strips. The beetles infested the undersides and shaded parts of the logs. Brood survival was good; the overwintering stages were protected from extremely low temperatures and woodpeckers by a blanket of snow. One to 2 years after logging operations ceased, the emerging beetles infested trees in the uncut strips.

The heaviest infestation resulting from logging operations was on Missionary Ridge, San Juan National Forest, where cull and 7,970 trees were heavily infested. The outbreak will be controlled with ethylene dibromide and logging. Similar outbreaks are being controlled on the Rio Grande and Grand Mesa-Uncompahgre National Forests.

The Illinois River infestation on the Routt National Forest is being controlled by natural factors, largely woodpeckers. The number of infested trees dropped from 600 in 1957 to 230 in 1958.

Figure I-1. --Cull logs and trees are ideal hosts for the Engelmann spruce beetle. Beetles attack the bottoms and shaded sides of culls. Cull in an overmature stand of Engelmann spruce makes up 15 to 40 percent of the volume.

Beetle populations are not yet serious in windthrown trees on the Eagle and Holy Cross Districts, White River National Forest, where a windstorm on September 13, 1957, blew down spruce in 19 patches 10 to 200 acres in size (fig. I-2). A sampling of the trees disclosed 0.04 beetle entrance and 2.29 eggs and larvae per square foot.

Black Hills beetle infestations increase in 1958

Infestations of the Black Hills beetle (Dendroctonus ponderosae Hopk.) cover 77,290 acres of the ponderosa pine type. Tree volume killed was 4 million board-feet. Increases were greatest in the Bighorn Mountains of Wyoming, the Black Hills of South Dakota, and east of the Continental Divide in Colorado. Landowners treated 6,852 infested trees during 1958. More than 4,000 of the trees were on the Bear Mountain District, Black Hills National Forest,

Figure I-2. --Tornadic winds in September 1957 blew down 19 patches of spruce on the Eagle and Holy Cross Districts, White River National Forest. Conditions such as this provide the spruce beetle with much host material. Entomologists keep a close check on the status of beetle populations in these trees until they are no longer susceptible to beetle attacks.

Mountain pine beetle epidemic on Shoshone National Forest

The mountain pine beetle (Dendroctonus monticolae Hopk.) continued to be active on 21, 500 acres of lodgepole and limber pine on the Shoshone National Forest. Approximately 4. 5 million board-feet of timber was killed. The Wiggins Fork infestation on the Wind River District built up to 9, 700 trees in 1958, an increase of 2, 200 trees from 1957. Outbreaks on the North and South Forks of the Shoshone River, Wapiti District, were controlled. During the past 3 years, approximately 12, 200 infested lodgepole and limber pines were treated.

Douglas-fir beetle infestations total 41,330 acres

Commercial stands of Douglas-fir in southern Colorado were depleted of 4.8 million board-feet of Douglas-fir in 1958 by the Douglas-fir beetle (*Dendroctonus pseudotsugae* Hopk.). Epidemic infestations continue on the San Juan, Grand Mesa-Uncompahgre, San Isabel, and Rio Grande National Forests, and the Sangre de Cristo Grant.

Bark beetles kill 6 million board-feet of subalpine fir

Infestations of the western balsam bark beetle (*Dryocetes confusus* Sw.) and fir engraver (*Scolytus ventralis* Lec.) are epidemic on 98,300 acres of spruce-fir type.

Spruce budworm infestations double

Spruce budworm (*Choristoneura fumiferana* (Clem.)) infestations cover more than 172,000 acres of fir and pine type in Colorado, an increase of 82,500 acres since last year. In general, defoliation was more intense in the infested area on the Rio Grande and San Juan National Forests. Top killing of trees was noticeable in the drainages heavily defoliated in 1957. Defoliation was light in the incipient outbreaks found on the Pike National Forest and the Sangre de Cristo Land Grant.

The Great Basin tent caterpillar outbreaks continue

The 1958 infestations of the Great Basin tent caterpillar (*Malacosoma fragile* Stretch) in aspen total more than 132,000 acres in southern Colorado. The aspen is dead on 1,180 acres following 9 years of heavy defoliation. Scattered trees are dying in many areas. Egg-mass counts forecast continued heavy defoliation for 1959. The caterpillar was controlled with DDT applied by airplane on 1,800 acres of aspen in Cucharas Camp on the San Isabel National Forest. The fall egg-mass survey shows heavy reinfestation by the moths from adjacent areas.

Large aspen tortrix and a pine needle miner

The large aspen tortrix (Archips conflictana (Wlk.)) is causing light to moderate defoliation in 220,450 acres of aspen in Colorado on the Grand Mesa-Uncompahgre, Gunnison, and San Juan National Forests.

Infestations of a pine needle miner (Recurvaria sp.) in ponderosa pine near Durango, Rye, and Colorado Springs, Colorado, reached 86,500 acres. Ten to thirty percent of the needles were mined.

FOREST INSECT CONDITIONS IN ARIZONA AND NEW MEXICO

Douglas-fir tussock moth -- a new defoliator

The Douglas-fir tussock moth (Hemerocampa pseudotsugata McD.), a destructive defoliator of Douglas-fir and true fir in the northern Rocky Mountains, was first discovered defoliating 100 acres of white fir on Pinal Mountain, Tonto National Forest, in August 1957 (figs. I-3, I-4, I-5). This infestation increased in 1958 to 2,500 acres. Three new light to heavy outbreaks were discovered in 1958: Arizona -- Baker Mountain (3,000 acres) Tonto National Forest; New Mexico -- Sandia Mountain (12,000 acres) Cibola National Forest, and Capitan Mountain (1,700 acres) Lincoln National Forest. The insect is feeding mainly on white fir and occasionally on Douglas-fir. Defoliation in parts of the Pinal Mountain outbreak was 100 percent. Tree mortality is expected where defoliation is above 80 percent.

Figure I-3. -- Douglas-fir tussock moth infestation, Pinal Mountain, Tonto National Forest.

Figure I-4. -- Douglas-fir tussock moth larva.

Figure I-5. -- Douglas-fir tussock moth egg mass on old cocoon — white fir.

Spruce budworm increases

Defoliation by the spruce budworm increased from 154, 950 acres in 1957 to 323, 840 acres in 1958. The mixed conifers on Carson and Santa Fe National Forests were hardest hit, with 139, 960 and 65, 160 acres of infestation, respectively. Feeding is moderate to heavy.

The outbreak on the North Rim of the Grand Canyon National Park and Kaibab National Forest was controlled by aerial spraying 100, 000 acres in June (fig. I-6). The treatment with 1 pound of DDT in fuel oil per acre killed 96 percent of the insects.

Figure I-6. -- Aerial spraying of DDT for control of the spruce budworm, Grand Canyon National Park and Kaibab National Forest.

Damage by pine bark beetles declines

A complex of Dendroctonus and Ips species was again associated with ponderosa pine kill on 534, 860 acres, as compared with 1, 735, 220 acres in 1957. Ips species, usually I. lecontei Sw., killed the top of the tree and Dendroctonus species, usually D. barberi Hopk., filled in and killed the lower sections. Other bark beetles were: D. convexifrons Hopk., D. parallelocollis Chap., and I. ponderosae Sw. Improvement of moisture conditions may be responsible for the decline of these beetles. Heavy losses for this year were on the Apache Indian Reservation, Coconino National Forest, and Cibola National Forest, where 112, 640, 63, 920, and 113, 160 acres, respectively, are infested.

Needle miner outbreak subsides

Defoliation by a needle miner (Recurvaria sp.), active since 1956 on ponderosa pine, was negligible in 1958. Causes for the decline are not known.

Another serious outbreak of fir engraver discovered

A fir engraver (Scolytus ventralis Lec.) outbreak of 4,480 acres was discovered in white fir on the Lincoln National Forest in 1958. This beetle continues to depredate the white fir stands on 10,000 acres in the Sandia Mountains east of Albuquerque, New Mexico.

Douglas-fir beetle damage declines

The Douglas-fir beetle killed 24.5 million board-feet of Douglas-fir on 670,860 acres in 1958, as compared with 96 million board-feet on 821,200 acres in 1957. Losses are heaviest on Cibola and Santa Fe National Forests. Much of the area is inaccessible or low in economic value.

Table I-1. --Summary of forest insect infestations in Arizona and New Mexico, 1958 season

Insect	Intensity of infestations				
	Light	Moderate	Heavy	Very heavy	Total
	Acres				
Pine bark beetles:					
Ips and Dendroctonus spp.[1]	424,460	72,960	18,880	18,560	534,860
Fir and spruce bark beetles:					
Douglas-fir beetle	373,360	197,640	74,740	25,120	670,860
Fir engraver beetle	--	2,920	1,200	12,160	16,280
Western balsam bark beetle	11,520	28,320	19,520	6,080	65,440
Engelmann spruce beetle	--	--	1,250	--	1,250
Defoliators:					
Spruce budworm	145,120	140,320	29,760	8,640	323,840
Douglas-fir tussock moth	--	17,200	2,000	--	19,200
Sawfly (ponderosa pine)	--	1,280	--	--	1,280
Great Basin tent caterpillar	--	89,320	8,000	126,300	223,620
Aspen leaf roller	--	1,280	--	--	1,280
Total	954,460	561,240	155,350	196,860	1,857,910

[1] Arizona five-spined ips associated with southwestern pine beetle and occasionally one or both of these associated with roundheaded pine beetle, larger Mexican pine beetle, and western six-spined ips.

RESEARCH

Sampling method developed for evaluating Engelmann spruce beetle infestations

The negative binomial distribution has been fitted to counts of Engelmann spruce beetle survival when such counts are made late in the life cycle of the beetle. This distribution is a "contagious" type where the presence of one insect increases the chance of finding others on the same sampling unit. The practical advantage of computing the distribution is for application of a sequential plan for sampling. The sequential plan involves a flexible sample size so that oversampling or undersampling can be avoided.

Sampling consists of removing two 6- x 6-inch bark samples from each of 25 trees and counting all living beetles in the samples. The samples are removed from the tree bole between 5 and 7 feet above the ground, one from the north and one from the south side of the tree.

In the development of this sampling procedure, some assumptions were made based on observations and data previously collected. First, no attempt was made to measure or estimate the number of beetles in a tree or in an area. This would require sampling of such intensity that no practical procedure could be hoped for. Instead, the sampling was designed to indicate population trends only. Second, the fluctuations as measured at one convenient location on the trees were assumed to be similar to fluctuations elsewhere in the tree. This assumption was found to be valid except for the lowest 5 feet of the bole where mortality is usually the least. However, this is not serious because insufficient numbers of beetles develop in the base alone to influence the course of an outbreak. Thus, fluctuations in the surviving populations above the base determine the trend of an infestation. Beetle survival as measured 5 to 7 feet from the ground was found to reflect trends of an infestation.

Population counts show infestation trend of Black Hills beetle

In July 1958, final counts were made in two areas on populations of the Black Hills beetle in trees infested in 1957. Both counts revealed high survival of beetles ready to fly; 64 per square foot on the Pike National Forest study area (fig. I-7) and 74 per

Figure I-7. --Sample trees on the Pike National Forest. Trees were treated after the population sampling was completed.

square foot on the Bighorn National Forest area. A prediction was made at that time that the number of 1958 infested trees would be larger than the number of trees killed in 1957. The prediction was not in error. Significant increases occurred in most Black Hills beetle infestations, especially in the Bighorn National Forest and the Black Hills National Forest.

Survival of Engelmann spruce beetle is less in upper bole

Survival of the brood of the Engelmann spruce beetle was measured in 25 trees 3 times during the life cycle at 5 to 7 feet and at 18 to 20 feet above the ground (figs. I-8, I-9). The results were as follows:

Date sampled	Stage	Beetle survival at 5-7 feet (No. per sq. ft.)	Beetle survival at 18-20 feet (No. per sq. ft.)
September 1957	Small larval	276.7	162.9
June 1958	Mature larval	33.3	11.0
August 1958	Adult	14.1	5.6

Figure I-8. --(Right) A 5- to 7-foot sample area on an Engelmann spruce tree. Both the 5- to 7-foot sample and the 18- to 20-foot sample can be seen on the spruce in the background.

Figure I-9. --(Left) Sampling at 18 to 20 feet on an infested Engelmann spruce tree.

<u>Details of method developed for systemic insecticides against Engelmann spruce beetle described in following seven photographs</u>

Figure I-10. --The test insecticide in water emulsion or solution is placed in holes drilled into the base of the tree at 4-inch intervals on the circumference. In 1 to 2 weeks, after the insecticide has been absorbed, the tree is felled. Sections are cut from various heights on the stem and moved to a central location for toxicity tests.

Figure I-11. --To establish artificial beetle infestations, a groove is gouged under a protecting flap of outer bark on a treated spruce. Then a piece of phloem containing eggs and first instar larvae is gouged from a nearby infested tree and transferred to the groove in the treated tree.

Figure I-12. --In this artificial infestation in a section from 30 feet high on the bole, the remains of 25 larvae were observed. The tree, 41 inches in circumference, was treated on July 23 with a total of 20 grams of dimefox placed in 10 auger holes.

Figure I-13. --Tunnels made by larvae in the phloem of an untreated spruce artificially infested at the transplant groove shown by an asterisk (*).

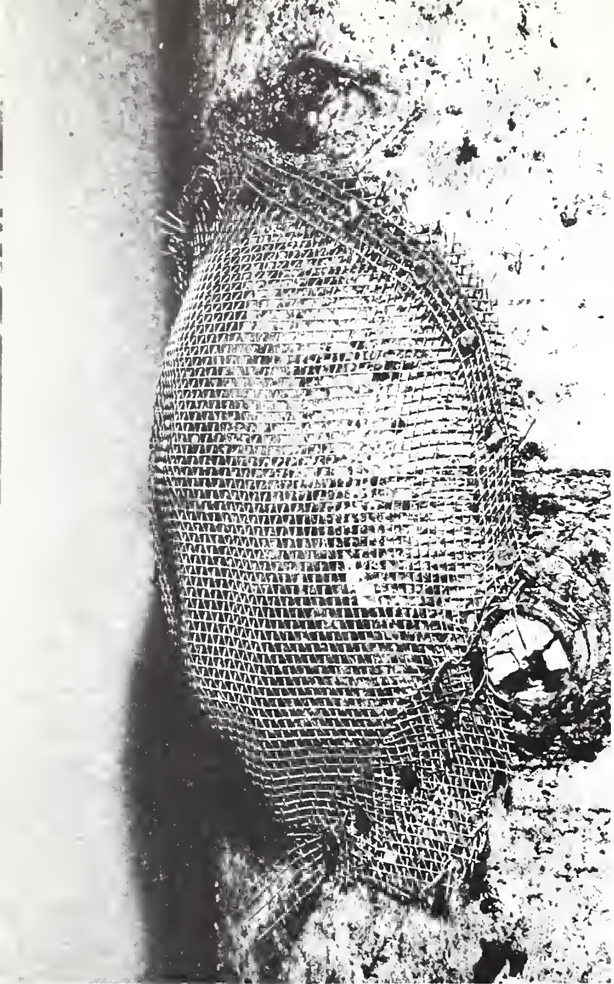


Figure I-14. --
The sections are also tested for toxicity to adult beetles by confining two pairs of beetles under a cage of wire screen nailed to the surface.

Figure I-15. --
In this section from 15 feet up the bole of the tree described in figure I-12, both pairs of beetles were killed. Three were imbedded in the abnormally shaped gallery, one was lying on the bark surface.

Figure I-16. --

Brood was successfully established by adult beetles in the bark of this section from an untreated spruce. The egg gallery does not show.

First-year results with polyhedrosis virus is promising in caterpillar control

Highest mortality of the Great Basin tent caterpillar from the disease was on 2 plots aerial sprayed with a dosage per acre of 30 billion polyhedra suspended in 2-1/2 gallons of water containing 20 percent corn syrup. Mortality was 41 percent on the Navajo Indian Reservation plot and 58 percent on the Carson National Forest plot. Even greater mortality is expected in these areas during the next 2 years.

On 7 other plots -- 2 on the Navajo Indian Reservation, 2 on the Carson, and 3 on the Rio Grande National Forests -- treated with the polyhedra suspended in water alone, the mortality ranged from 0 to 28 percent. A total of 2,000 acres of heavily infested aspen was sprayed.

Pinyon protected from *Ips* beetle attack

Pinyon pines threatened with *Ips* bark beetle attacks can be protected by spraying the stem with a 2 percent emulsion of DDT. Approximately 1,300 trees were treated; 130 check trees remained untreated. Results of a pilot test at Grand Canyon showed that 2 applications of the spray (April and June) prevented any mortality among the sprayed trees, while 3 percent of the unsprayed trees were killed. Approximately 1 gallon of spray covers a pinyon pine 15 feet tall.

Life history of *Ips* in pinyon

A five-spined engraver tentatively identified as *Ips confusus* (Lec.) was found to have 3 and possibly 4 generations a year. It will attack and kill healthy pinyon, but when populations are declining as they were in 1958 at Bandelier National Monument, attacks were confined to pinyon defoliated by a twig borer.

The first generation required an average of 55 days from the initial attack to the emergence of the brood; the second, 29 days; and the third, 33 days. The fourth generation is overwintering and will attack trees next spring.

Approximate times for each stage to develop are:

Eggs	-	6 days
Larvae	-	15 days
Pupae	-	7 days
Callow adult to emergence	-	7 days

Three females to each male were taken from the egg galleries; sex ratio of emerging beetles was approximately equal.

Nematode parasites of bark beetles

As part of the program to learn more about the natural mortality factors of bark beetles, studies continued on the nematode parasites and associates of *Ips confusus* (Lec.). In 1957, 615 beetles were examined from 17 trees; 41 percent were infested with *Aphelenchulus* sp. Male and female beetles were infested in equal numbers. In 1958, 568 beetles were examined from 21 trees; 28.7 percent of

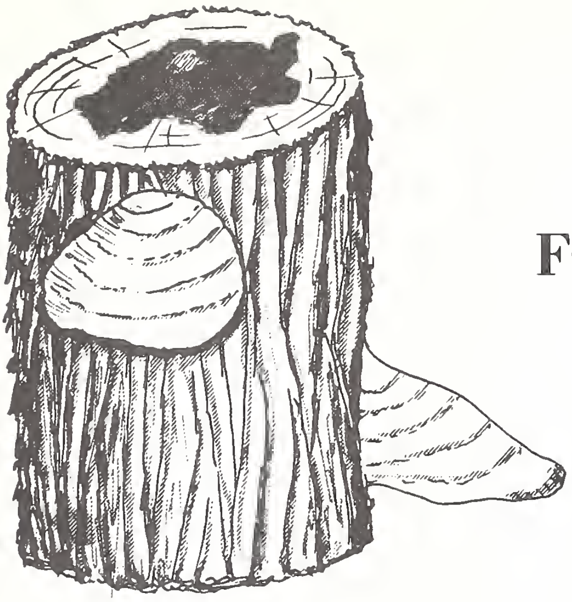
the insects were infested. Parasitism of the four generations in 1958 was as follows:

Generation	Beetles infested with parasite: Male	Female	Both sexes
	- - - (Percent) - - -		
I	14.2	38.8	34.0
II	20.8	35.7	33.3
III	7.1	16.6	16.0
IV	28.5	12.9	17.3

The beetle infestations in pinyon declined drastically in 1958. Few beetles were available for study during the latter part of the year because of the natural decline. Nematode parasites may have contributed to the decline.

Nematode parasites affect egg laying of a bark beetle

Pairs of the bark beetle *Ips confusus* (Lec.) were placed in small muslin sacks containing green bolts of pinyon pine and then placed in a rearing cabinet with a constant temperature of 80° F., and relative humidity 80 percent. One series was examined after 2 weeks to learn the effect of *Aphelenchulus* sp. upon the number of eggs laid. The other was examined in 4 weeks, after the eggs had hatched and the larvae were developing to learn the effect upon the brood. The infested beetles laid 12.5 eggs per female in a 2-week period as compared with 26 eggs per uninfested female, a reduction of 52 percent. Brood produced by infested females averaged 24.3 per individual as compared with 57.9 per uninfested female, a reduction of 58 percent. The brood was more likely to be infested with nematodes when the females or both sexes were infested than when males alone were infested. Forty-seven percent of the brood was infested when the adult female was parasitized; 53 percent, when both adults were parasitized; and 6.2 percent, when males were infested with *Aphelenchulus* sp. Egg galleries constructed by parasitized beetles averaged 4.5 inches in length; egg galleries of non-infested beetles were 7.1 inches in length.



FOREST DISEASE RESEARCH

Cedar planting stock freed of nematodes by hot water

Assistance was given in developing a hot-water treatment for 40,000 red cedar seedlings infested with parasitic nematodes at the Bessey Nursery, Halsey, Nebraska. Various time-temperature schedules based on successful experience reported for agricultural crop plants were tried. All treatments were lethal to the eelworms, and current indications are that two schedules will insure good survival in outplantings. Soil fumigants for controlling nematodes are also being tested in the nursery.

WOOD DECAYS

Decay losses in aspen summarized

Analyses of decay in about 1,000 aspen trees shows a definite relationship between decay and age, and between amount of decay and site quality. In stands older than 100 years, the amount of decay was about three times as high on site 3 as on site I. *Fomes igniarius* var. *populinus* (figs. D-1, D-2) was the most important decay fungus in aspen. It accounted for about 60 percent of the total decay. Infections of *Cryptochaete polygonia* (figs. D-3, D-4) were encountered more frequently than any other fungus in aspen but caused only about 10 percent of the total decay.

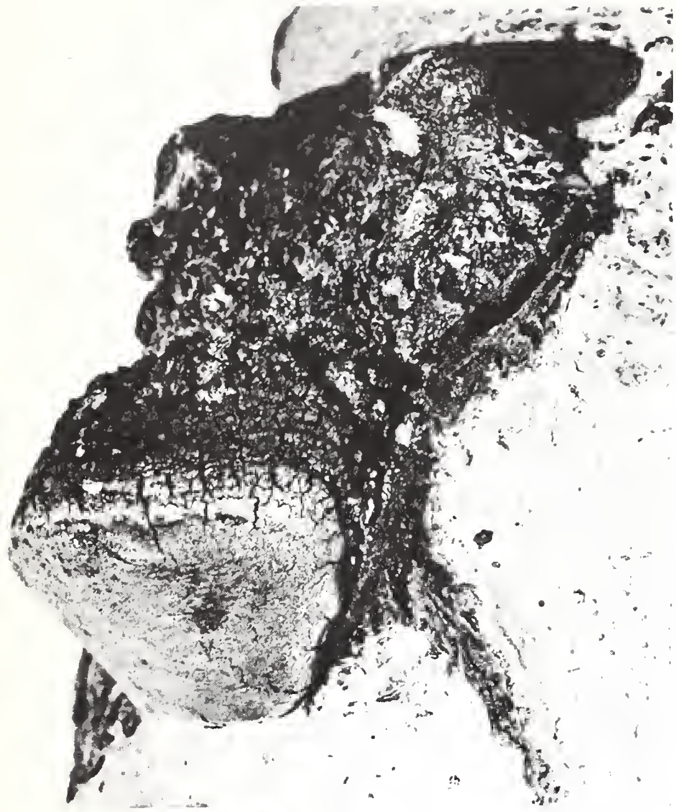


Figure D-1. -- Conk of Fomes igniarius var. populinus. This fungus caused 60 percent of the decay in 1,000 quaking aspens dissected on the Western Slope of the Rockies in Colorado.

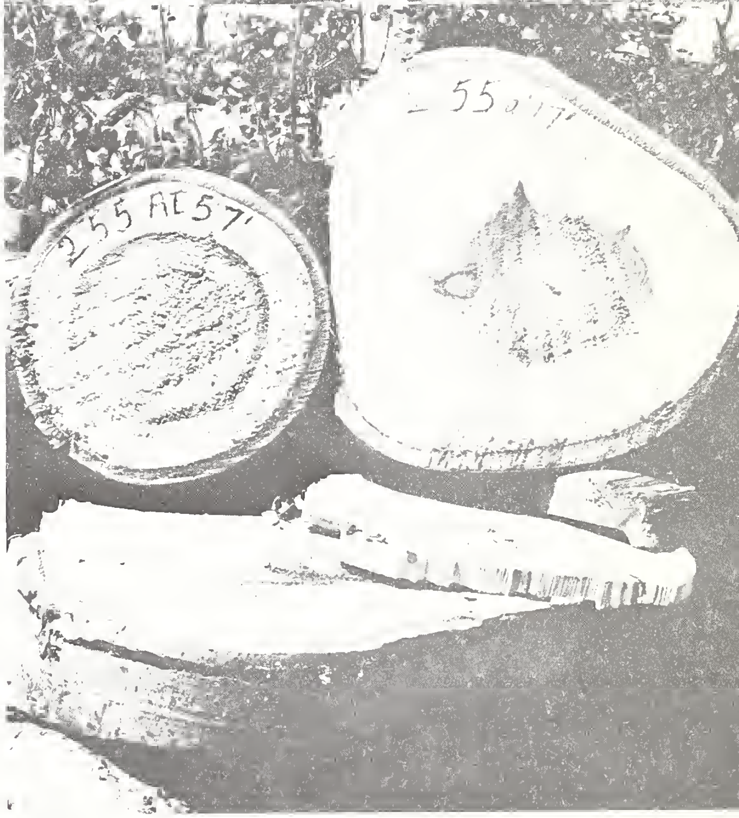
Figure D-2. -- Cross section of a quaking aspen bolt ruined by F. igniarius decay.

Figure D-3. --

The lichen-like fruiting bodies of Cryptochaete polygonia are more common than the conks of F. igniarius, but this fungus caused only 10 percent of the total decay.

Figure D-4. --

Quaking aspen bolts rotted by C. polygonia.



Beetle-killed spruce deteriorates faster in Colorado than was anticipated

Interim results indicate that the rate of deterioration of beetle-killed spruce is faster than had been anticipated from studies of a similar epidemic in Engelmann spruce in Utah. In Colorado, indications are that the original gross cubic-foot volume will be reduced by about one-third after 15 years from the time of peak beetle activity (fig. D-5). The loss is equally divided between windthrow and decay in dead standing trees.

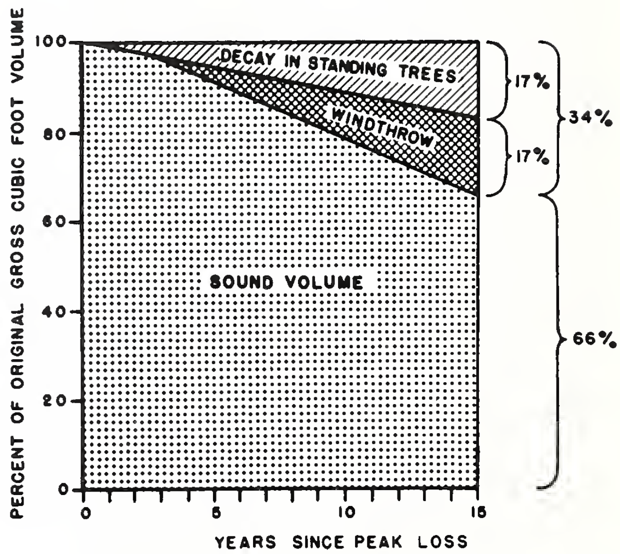


Figure D-5. --Trend of loss in beetle-killed Engelmann spruce in Colorado based on observations in epidemic areas began in 1951. The 15-year loss is 34 percent of the gross volume divided equally between windfall and decay in standing trees. Sap rot losses are heaviest in the butt logs of standing trees.

Mortality losses probably explain soundness of overmature ponderosa pine

Studies in cooperation with the U. S. Bureau of Indian Affairs and the Navajo Tribe suggest that natural mortality accounts for the relative soundness of old ponderosa pine in virgin stands on the Defiance Plateau in northern Arizona. This agrees with earlier findings on the Fort Valley Experimental Forest, where examination had been limited to trees removed in a second cutting. Low incidence and volume of red rot in the older age classes therefore may have resulted from the removal of the most defective trees in the first cut.

On the Defiance Plateau gross volumes as well as red rot volumes were generally less in trees older than 250 years than would be expected from the volume trends established by the

younger age classes, but there was considerable fluctuation between means for successive 20-year age classes. This is reminiscent of what has been termed the cyclical development of conk rot in Douglas-fir stands of Oregon, which is associated with the pathogenic action of *Fomes pini*. It is not believed that *Polyporus anceps*, the cause of red rot, is a mortality factor in overmature ponderosa pine. Death from other causes occurs most frequently among the largest trees in a stand, and they usually contain the greatest volumes of decay.

In the development of a means for predicting rot increment in residual stands where mortality was virtually eliminated by the first cutting, curves fitted to the entire range of ages tend to minimize losses that can be anticipated in second and succeeding cutting cycles.

External indicators promise better cull estimates in spruce

Dissections of about 550 merchantable Engelmann spruce trees from all Colorado national forests relate decay cull to external indicators. Starting with a score or more of possible indicators, the preliminary analyses have reduced these to seven that are consistently associated with decay as shown in the following list. The percent of frequency of rot association was computed by dividing the number of times the indicator was associated with decay by the total occurrence of the indicator.

Indicator	Percent
Conks or punk knots	100
Broken tops	96
Dead rust brooms	68
Basal wounds	66
Frost cracks	58
Old dead tops	46
Trunk wounds	44

Field trials will be made in 1959 to develop a simple sampling technique to improve estimates of decay.

Figure D-6. --Conks or punk knots of Fomes pini are sure indicators of decay. Decay extended for an average of 25 feet above the highest visible conk or punk knot.

Figure D-7. --Sixty-eight percent of the dead rust brooms were associated with decay and 46 percent of the trees with old dead tops had top rot.

Figure D-8. --Decay was associated with 58 percent of the frost cracks.

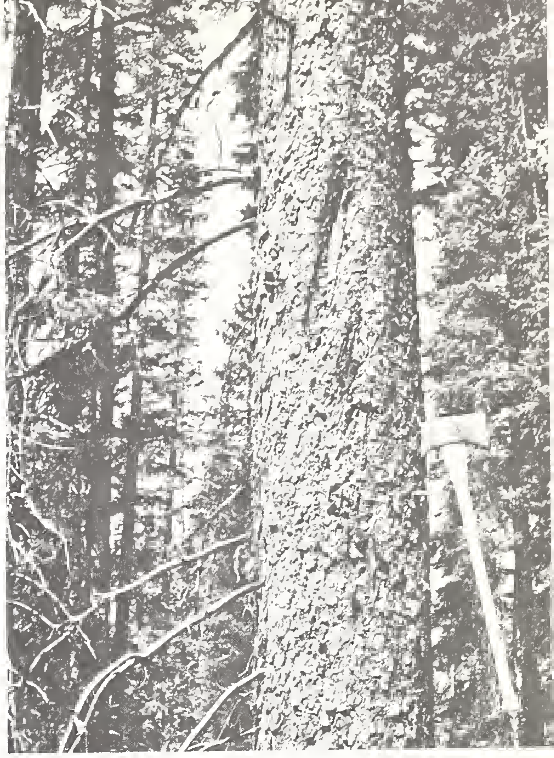


Figure D-9. --Forty-four percent of the trunk wounds were associated with decay.

Figure D-10. --Top rot was found in only 8 percent of the trees with recent dead tops. This indicator was discarded.

Figure D-11. --Only 4 percent of these spruce cankers of unknown origin were associated with decay. This indicator was discarded.

FOLIAGE DISEASES

Needle cast on ponderosa pine in Arizona worse in 1958

Needle cast of ponderosa pine was more severe in 1958 than in 1957. The disease appears to be established in the Hassayampa Lake area of the Prescott National Forest and the Munds Park-Weimer Springs Road area on the Coconino National Forest. Neither area could be identified from the air with certainty as in 1956 when they appeared uniformly scorched, but ground inspections showed that both had sizable centers of severe needle discoloration. Disease persistence is problematical in the Methodist Camp and Mingus Mountain areas on the Prescott and the Stone Lake-Allan Lake area on the Coconino National Forest. These were examined repeatedly during 1958 and appeared to be only lightly or moderately affected. Other previously reported centers either were examined a few times on the ground or they were observed from adjacent high points. Discoloration visible from a distance indicated that none of the centers had needle cast comparable to the 1956 outbreak.

Preliminary analyses in other areas indicate that (1) needle cast was present on 60 percent of the trees in lightly infected stands, on 71 percent of those in moderately infected stands, and on 100 percent of the trees in heavily infected stands; (2) in diseased stands needle retention was consistently better on healthy than on diseased trees; and (3) needle cast intensity varied inversely with tree size and crown class -- it was most severe on seedlings, saplings, and on suppressed trees.

Field observations and laboratory studies in 1958 revealed that of the true needle cast fungi, *Hypodermella medusa* and *H. concolor* were most widespread. They occurred in the two areas on the Prescott and Coconino National Forests, where the disease seems to be persisting, as well as in the Pinaleno Mountains of the Coronado National Forest. In the latter, trees were severely attacked by needle cast fungi in four distinct centers. In one of these, the affected trees had a scorched appearance.

A *Diplodia*-like species associated with severe needle necrosis, and in some instances fruiting in old needle-cast hysterothecia in several disease centers, was found for the first time in 1958 (fig. D-12). In contrast to some previous years, no substantiation of reports of occurrence were found

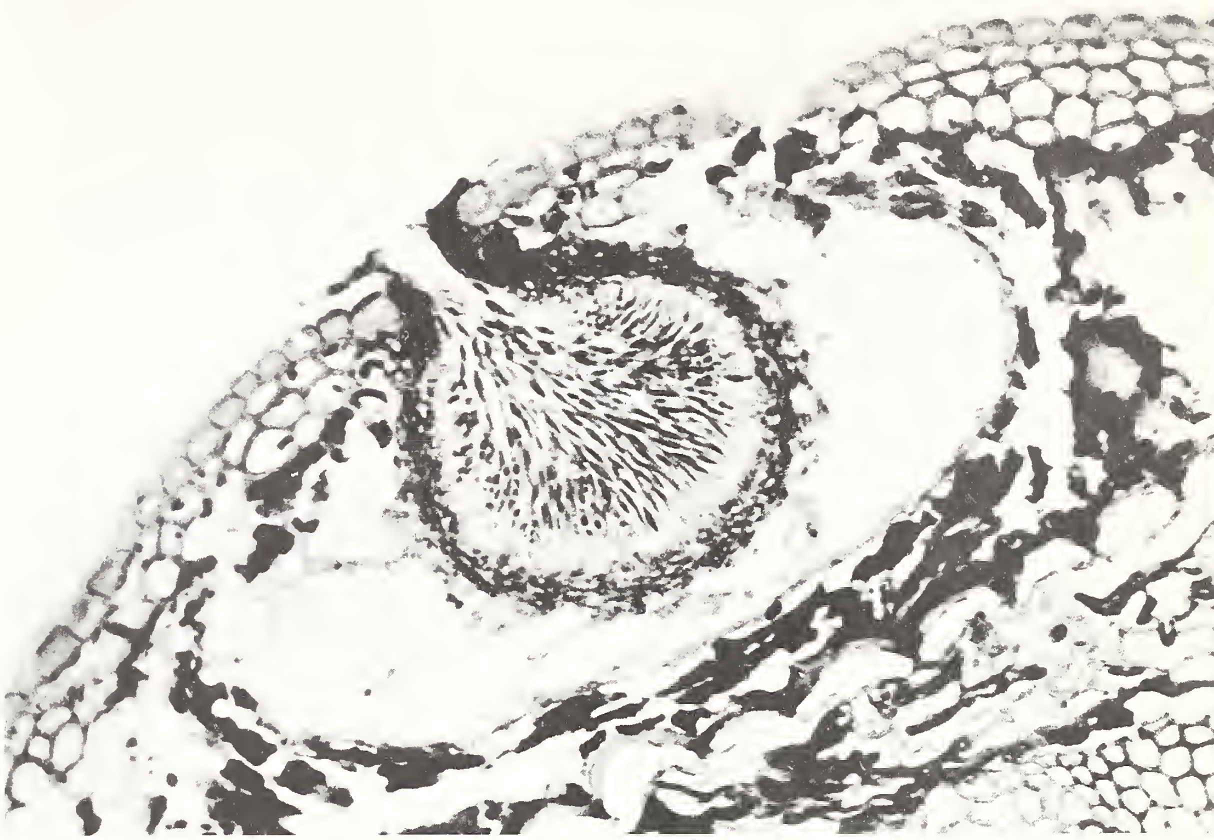


Figure D-12.--Photomicrograph of transverse section of ponderosa pine needle showing a pycnidium of the Diplodia-like fungus that developed in what appears to be a hysterothecium of a needle cast fungus. Magnification, 330 times.

of the brown spot fungus (Lecanosticta acicola) in association with this disease during the year. Few cases of the related Dothistroma pini were encountered. Table D-1 shows the distribution of the associated fungi in 1958. This work is in cooperation with the Department of Plant Pathology, University of Arizona.

Table D-1.--Distribution of fungi associated with needle cast of ponderosa pine, 1958.

Location	Diplodia-like sp.	Hypodermella medusa	Hypodermella concolor	Elytroderma deformans[1]
Kaibab National Forest (North):				
Jacob Lake	--	x	x	x
Coconino National Forest:				
Fort Valley	--	x	x	x
Munds Park-Weimer Spring Road	x	x	x	x
Stoneman Lake	--	x	x[2]	x[2]
Prescott National Forest:				
Hassayampa Lake	--	x	x	x
Coronado National Forest:				
Pinaleno Mountains	x	x	x	x
Santa Catalina Mountains	--	x	Rare	x

[1] Occasional trees in all areas but probably not associated with needle cast under study.
[2] Also in adjacent Allan Lake area.

Minor damage to foliage of other species

The aspen leaf blight caused by *Marssonia populi* was common on western Colorado national forests in 1958, and a heavy area of infection of the aspen leaf rust *Melampsora* sp. was seen on the Roosevelt National Forest. Leaf rusts were also common on narrowleaf and lanceleaf cottonwoods and willows in the Front Range of Colorado.

Needle cast fungi were prevalent on Engelmann spruce, white fir, corkbark fir, and limber pine in Arizona and New Mexico. Resulting needle discoloration was especially severe in the San Francisco Mountains of the Coconino National Forest. Several administrative detection reports were investigated during the year.

DWARFMISTLETOES

New findings on lodgepole pine dwarfmistletoe

Preliminary observations and indications regarding the dwarfmistletoe attacking lodgepole pine (*Arceuthobium americanum*) are as follows:

1. Peak seed dispersal in 1958 was on August 21; 95 percent of the crop was discharged in a 3-week period, about 1 month later than has been determined for the ponderosa pine parasite (*A. vaginatum*).

2. The angle of discharge was more nearly horizontal than in *A. vaginatum*, suggesting that height of origin may have more effect on horizontal spread in lodgepole pine stands than in ponderosa pine.

3. There were two new developments in possible biological control. An unidentified pathogenic fungus now under study was found attacking 85 percent of the dwarfmistletoe shoots in one area. Adults of a Tortricid, the larva of which is considered to be the most important enemy of dwarfmistletoe, were obtained for the first time and have been submitted for identification.

4. Chemical control tests were made in cooperation with the Timber Management Division of the Forest Service, Region 2; the Upjohn Company; and the Naugatuck Chemical Division of the United States Rubber Company. The industry cooperators furnished the Acti-dione and maleic hydrazide, respectively, that were used this year. At least one more season will be needed before the results can be evaluated.

Guides for pruning dwarfmistletoe-infected branches

Six years ago, 447 mistletoe-infected ponderosa pine branches were pruned to determine how far the proximal dwarfmistletoe shoots must be from the trunk to be reasonably sure that the absorbing system of the parasite had not entered the main stem. Thus far, shoots indicative of bole infections have appeared at 50 pruning wounds; 15 of these developed in 1958, which suggests that all bole infections have not yet revealed themselves. The following "safe pruning" distances are suggested, pending further analysis.

Branch, diameter outside bark (Inches)	Minimum distance from shoot to bole (Inches)
0 - 1.0	6
1.1 - 2.0	8
2.1 - 3.0	10
3.1 - 4.0	12

MISCELLANEOUS DISEASES

New information on hip canker (*Peridermium harknessii*) of lodgepole pine

The rust mycelium was found to grow mainly in the horizontal direction, with only occasional narrow, vertical extensions. Thus seedling lodgepole pines with appreciable annual increment are seldom girdled by the fungus. In understocked infested stands, cankered trees will survive to maturity, but cull allowance must be applied to sawtimber volumes or cankered trees must be subtracted from estimates for pole cuts. In dense stands where growth is slow, cankered trees are usually girdled in the sapling or early pole stages, and little loss is held over until cutting. If trees reach

sapling size without infection, they are seldom attacked by the rust in Colorado and Wyoming, and even then the damage is slight.

Rust spore dissemination from infected pines was found to extend from 1 to 2 months at a given location. The length of the dissemination period and times of maximum dispersal are linked closely with humidity; high and changing relative humidity favor spore discharge. Most infections on pine result from spores produced on the rust's herbaceous hosts, Indian paintbrush and owlclover, in July and August. Only certain years, such as 1945 and 1949, in the Front Range provide the precise climatic conditions needed for abundant infection of pine.

Abnormal juniper mortality declining

Juniper mortality in Arizona and New Mexico subsided during 1958. No new foliage discoloration was seen on a series of study plots on the Prescott, Coconino, and Cibola National Forests, where mortality had been spectacular in 1957. During the year isolations were made at regular intervals from branches and roots of healthy as well as affected trees. No one fungus was consistently isolated, although a dematiaceous mold, possibly a *Coniothecium*, was most commonly cultured.

Hypoxylon canker of aspen widespread in Colorado

Observations indicate that hypoxylon canker (*Hypoxylon pruinatum*) is widespread in aspen in western Colorado. In 1958, it was seen for the first time in Wyoming (Encampment District, Medicine Bow National Forest) and also for the first time on the eastern slope of the Rockies in Colorado (Lake San Isabel, San Isabel National Forest).

Sooty bark canker is serious problem in aspen management

An analysis of inoculations made with *Cenangium singulare*, the fungus that causes sooty bark canker, indicated that infection readily takes place through fresh wounds of bark or wood. Although the basis for old wound and branch stubs was small, no

infections resulted. Cankers developed rapidly and the rate of lateral invasion or girdling effect of the cankers averaged 7 inches after 1 year, with a maximum of 15 inches. Observations in cutover aspen stands in western Colorado indicate that sooty bark canker is very damaging; presumably logging injuries on residual trees furnished ideal points of entry for the fungus.

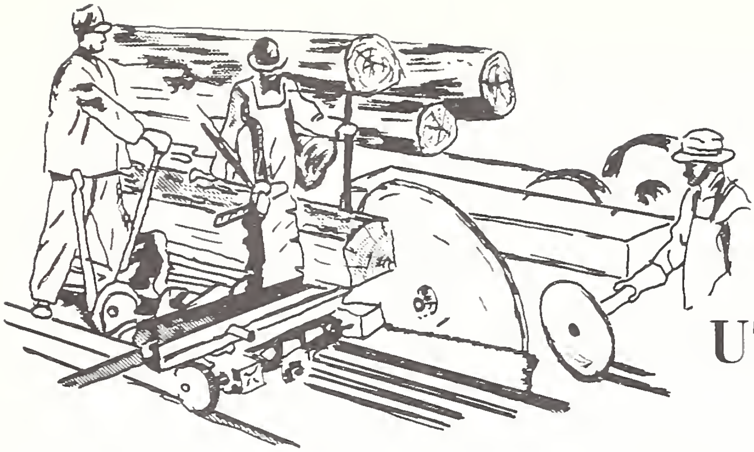
Armillaria root rot threatens lodgepole pine regeneration

Armillaria root rot is widespread in young lodgepole pine stands established in cutover areas in various national forests of Colorado and Wyoming. Although only a small percentage of the trees have been killed to date, the disease has a serious potential in that it is generally distributed throughout most of the cutover areas examined. The disease typically radiates out from infection centers and kills groups of trees around the margin.

Forest micro-fungi prevalent during 1958

Weather conditions were again favorable for fruiting of forest fungi and a number of species new to Arizona and New Mexico were collected-- some for the second season. Among these were three species of *Valsa* (*Cytospora*) on white fir; a *Daldinia*, *Valsa*, and a *Cytospora* on aspen; a *Phoma* on limber pine; and a number of fungi on yucca.

Mortality among planted cottonwoods in Big Bend National Park continued in 1958 as in the preceding year, when it was first reported. A *Fusarium* has been isolated from specimens of root crowns and dead lateral roots, but there has been no opportunity to test its possible role as a disease agent.



FOREST UTILIZATION RESEARCH

Lumber recovery in the Black Hills

Results of a lumber-grade recovery study of ponderosa pine in the Black Hills based on the output of 4 mills showed that 90 percent of the lumber was in common grades. About 21 percent was No. 1 and No. 2 common; 35 percent, No. 3; 29 percent, No. 4; and 5 percent, No. 5. Select, molding, and shop grades made up the remaining 10 percent (table U-1). Lumber was graded by the Western Pine Association.

Table U-1. --Lumber-grade recovery from 1,840 ponderosa pine logs at 4 mills in the Black Hills, based on shipping tally

Lumber grade	Condition of logs		
	Sound	Defective	All
	- - - Percent - - -		
Select:			
C and better	0.1	1.1	0.6
D	2.8	4.0	3.3
Moldings	2.3	4.6	3.3
No. 1 shop and better	2.2	3.4	2.8
Common			
No. 1 and 2	27.3	12.4	20.7
No. 3	39.1	30.3	35.1
No. 4	23.1	36.2	28.9
No. 5	3.1	8.0	5.3

Overrun based on a shipping tally of 140,888 board-feet ranged from 18 to 41 percent and averaged 29 percent. Sound logs produced less overrun than defective logs--19 percent compared with 43 percent. Sound logs, however, averaged 4 to 36 board-feet more lumber than defective logs and had a higher value per M board-feet--$76.15 compared with $69.94.

Overall volume losses due to kiln drying were only 2.6 percent. The greatest reduction, a 55-percent loss, occurred in select grades. Grades No. 1 and 2 common followed, with a loss of 24 percent. The volume losses within grades were largely made up by an increase in No. 4 common grade.

The percentage of common grade was high because of the relatively small diameter of the sawtimber in the Black Hills. The average log, small end (d.i.b.) was 11.1 inches, with the greatest number falling in the 9-inch diameter class (fig. U-1). The logs ranged between 8 and 16 feet in length, with 75 percent in the 16-foot class. Seventy percent of the lumber cut was in 6- and 8-inch widths.

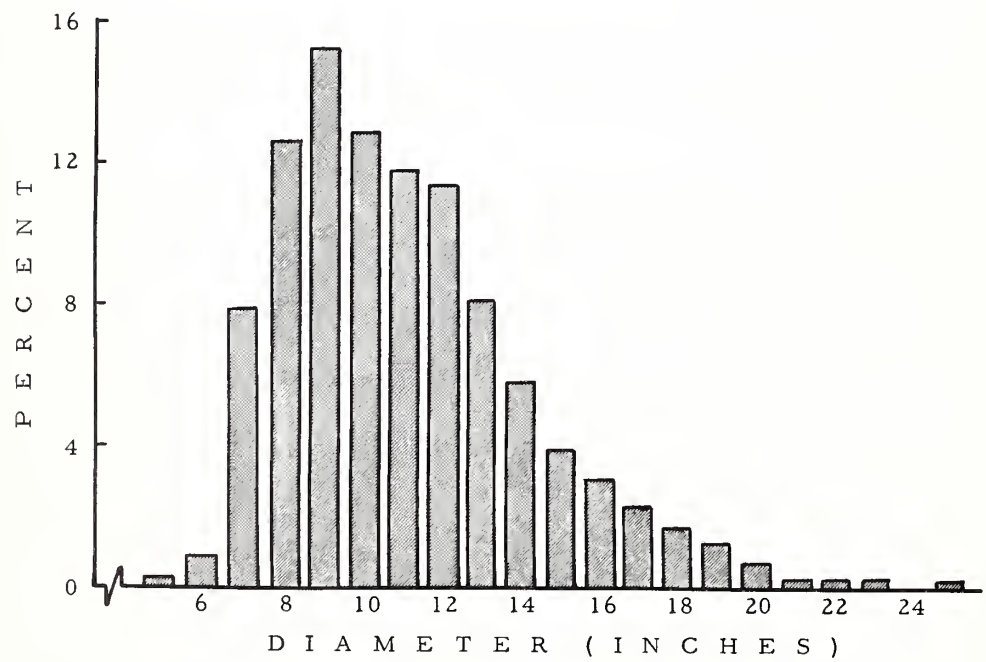


Figure U-1.--Distribution of log diameters -- 1,840 Black Hills ponderosa pine logs.

The Pacific Northwest log-grading system was tested, but it was not satisfactory. However, grading systems will be further studied by a National Task Force.

Lumber recovery in Arizona

In Arizona ponderosa pine, shop grades made up 21.9 percent of the total lumber yield (table U-2), compared with 2.8 percent in the Black Hills. The relationship was reversed in grades No. 1 and No. 2 common, where the yield was 20.7 percent in the Black Hills compared with 1.46 percent in Arizona. The generally larger diameter and greater age of the Arizona pine, together with the fact that age classes are more uneven, account for much of this difference. As shown in figure U-2, the largest number of Arizona ponderosa pine logs fall in the 23-inch diameter class.

Table U-2. --Dry lumber recovery by lumber grades and log grades, 537 logs, ponderosa pine from Arizona

Lumber grade	Log grade						Total
	I	II	III	IV	V	VI	
	Percent						
Select							
B and better	1.68	0.81	0.35	0.54	0.10	0.04	0.41
C	2.39	1.18	.54	.81	.19	.09	.62
D	12.06	6.08	2.95	4.12	1.17	.67	3.33
Molding	20.45	14.68	9.20	7.34	2.48	1.51	7.91
No. 3 clear	2.85	3.34	3.93	4.36	2.82	2.07	3.21
Shop							
No. 1	6.84	7.86	8.63	6.80	7.09	5.79	7.54
No. 2	5.57	6.66	9.72	1.65	9.26	5.68	8.22
No. 3	3.07	4.22	7.18	.54	7.35	4.85	6.10
Common							
No. 1	.15	.10	.06	.08	.02	.03	.06
No. 2	1.88	2.06	1.50	1.87	.90	1.27	1.40
No. 3	14.91	18.95	17.65	34.86	17.02	20.75	17.91
No. 4	19.54	23.89	27.42	28.20	35.20	38.96	30.02
No. 5	8.61	10.17	10.87	8.83	16.40	18.29	13.27

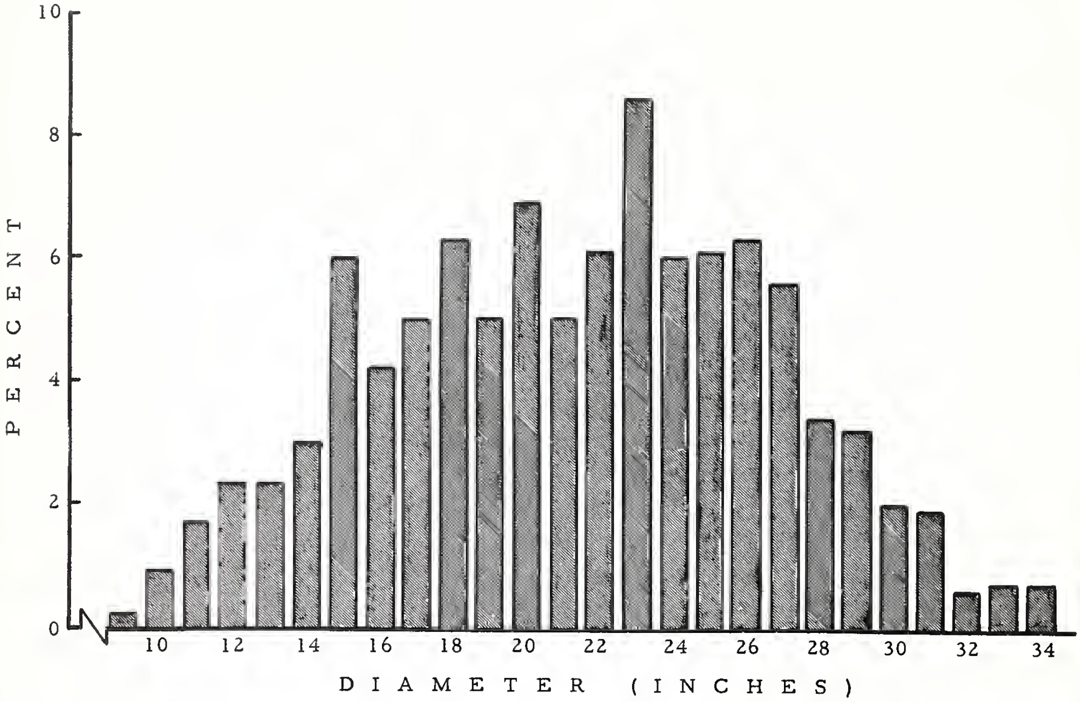


Figure U-2. --Distribution of 16-foot logs by diameter classes, top d. i. b., ponderosa pine in Arizona.

Logging with Skyline-Crane on steep slopes

Overhead cable logging tests of the Wyssen Skyline-Crane were continued in 1958 on the Fraser Experimental Forest in Colorado, in cooperation with Koppers Company, a private logging contractor.

Operation costs for 1958 were as follows:

Productive crew hours per 8-hour day . . . (Travel, demonstration, breakdown, and maintenance time not included)	5. 3 hours
Average volume skidded and yarded per productive crew hour	559 board-feet
Average number of logs per M b. m. . . .	14 logs

Operating costs per M b.m.:

Labor (logging only)	$14.22
Labor (maintenance and repair) . . .	6.44
Labor (installation)	4.85
Gasoline, oil, and lubricants	.27
Reserve supply fund . . . . (includes a parts replacement account)	3.00
Depreciation	1.00
	$29.78

Crew efficiency was better than for previous years because experienced crew members were used. Cost of moving to new settings was lowered. Total operation costs increased slightly, however, because of higher wages and increased maintenance, repair costs, and labor turnover.

Beetle-killed Engelmann spruce makes good particle board

Beetle-killed Engelmann spruce from the White River National Forest in Colorado, heart of the beetle infestation, was evaluated for the production of the flake and hammermilled particle board (fig. U-3). Results were favorable. No difficulties were encountered in processing either type of board. The material flaked well and, with one minor exception, the boards satisfactorily met all strength requirements. If the density of a spruce panel were increased to that of a heavier wood, the strength properties would of course be greater.

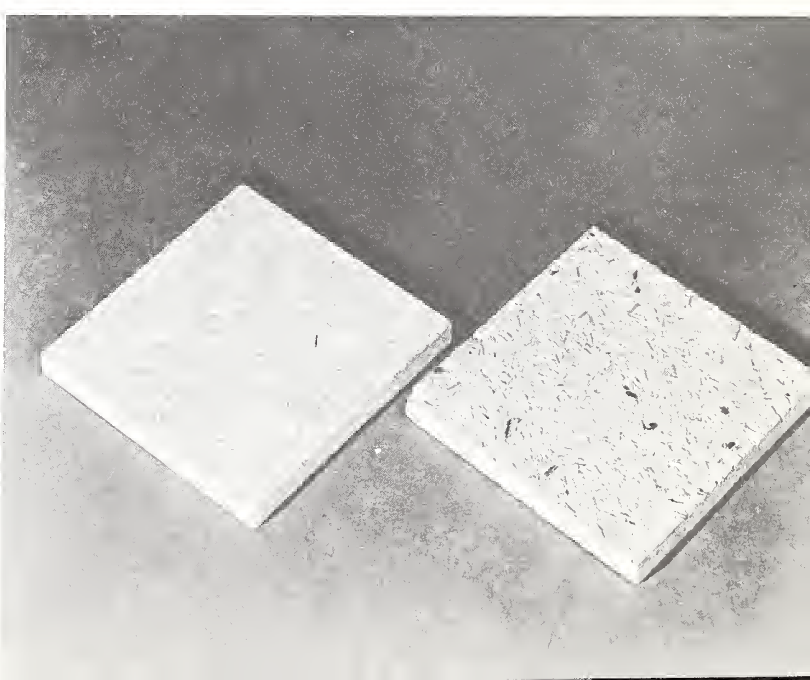


Figure U-3. -- Samples of particle board produced from beetle-killed Engelmann spruce. (Left) Flakeboard. (Right) Hammermilled.

Figure U-4. -- Aspen veneer bolts at new plant in Montrose, Colorado. (Veneer cores in background.)

Colorado aspen basis of three new industries

Veneer was produced commercially for the first time in the Rocky Mountain area by a new plant at Montrose, Colorado. The plant uses aspen, which it finds excellently suited for the purpose (fig. U-4). The operation is integrated with lumber production to make possible the utilization of all grades of merchantable logs.

An important advance in secondary manufacturing practices came with the establishment of an edge-glued lumber core plant at Montrose, Colorado (fig. U-5). The new factory will feature aspen, which, due to its soft texture, is well suited for gluing. The grain pattern of harder textured woods tends to telescope through the face panels and are therefore objectionable for such uses as high-quality table and desk tops and related products. Built-up cores, or those made up by edge gluing numerous strips, have less tendency to warp than those made up of wider boards. Consequently, they are preferred for such uses where warping is a problem. Suitable core material must be available to furniture and door factories.

Excelsior fibers bonded with a specially formulated Portland cement provided the basis for a new industry at Littleton, Colorado (fig. U-6). This material, formed into 2- x 8-foot and 4- x 8-foot sheets varying from 1 to 3 inches in thickness, is finding a ready market as roof decking and wall sheathing. Its high fire resistance and good insulation properties make it especially desirable for school construction. It can be easily nailed and sawed, and is vermin proof. The process utilizes fibers that are not acceptable for excelsior because of color or odor. It, therefore, integrates excellently with the production of excelsior, where as much as 30 to 35 percent of the volume of the bolts is rejected.

Figure U-5. --Section of aspen lumber core manufactured at Montrose, Colorado.

Figure U-6. --Cement-bonded aspen excelsior board.

Seasoning checks weaken lodgepole pine utility poles

Reports were received from utility firms in eastern Colorado that pressure-treated lodgepole pine poles were deteriorating in 8 to 10 years. Normal service life expectancy is 30 to 35 years. Inspection revealed that because of improper seasoning about 2 percent of the poles had checked after treatment and installation (fig. U-7). These checks exposed untreated wood and allowed wood-decaying fungi to enter. Lodgepole pine and other species with thin sapwood have this weakness. But it can be offset through careful seasoning.

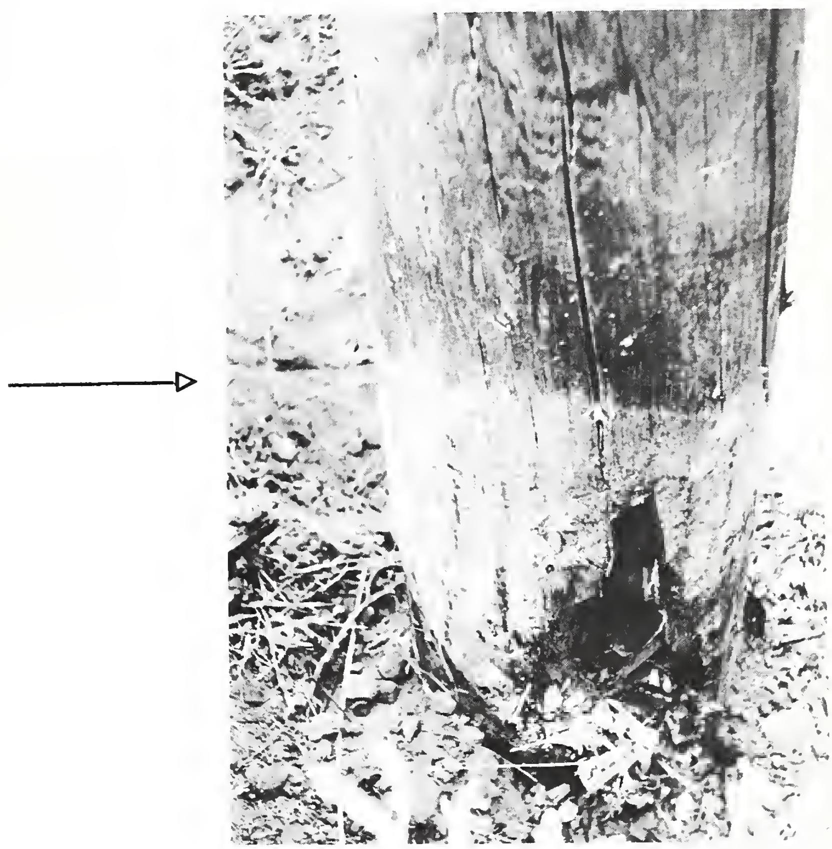


Figure U-7. --Premature failure in pressure-treated lodgepole pine pole resulting from seasoning check. Normal ground line is shown by arrow. (Photo -- Courtesy Colorado State University)

Chemical peeling in the Black Hills

Overwintering has helped loosen the bark of poisoned trees in some areas. However, in the Black Hills it did not improve peeling of trees poisoned between May 20 and June 18. Ponderosa pine treated during this period were easier to peel in November than in the following May. Only for trees poisoned in August did overwintering show any benefit (fig. U-8).

Figure U-8. --Large chunks of bark easily removed with peeling spud are characteristic of a satisfactory peelability rating. These bolts are from Black Hills ponderosa pine trees treated May 20 to June 18 and harvested in November.

An index of 0 to 9 was used to classify the effectiveness of treatment. A rating of 5 is comparable to sap peeling, that period when bark is most easily removed naturally. Figure U-9 shows the results graphically.

Stain and insect work in poisoned trees was not extensive. Trees harvested in November showed less stain than those harvested in May. Surface and blue stain were heaviest in the

upper bolts, with lower bolts often free of stain. Surface stain had entered holes in the bark, caused mainly by bark beetles. Damage by wood borers was minor.

Response to poisoning was first visible 1 or 2 weeks after treatment. During this period needles faded to a yellow green or light brown, then to a reddish brown at about 4 weeks; and defoliation started between 4 and 8 weeks after treatment, depending on the treating date.

Trees were poisoned with a 40-percent solution of sodium arsenite during the spring and summer. At each treating date the trees were girdled at stump height, and two coats of the chemical were brushed on. Girdle width approximated d.b.h., which ranged from 6.1 to 11.1 inches.

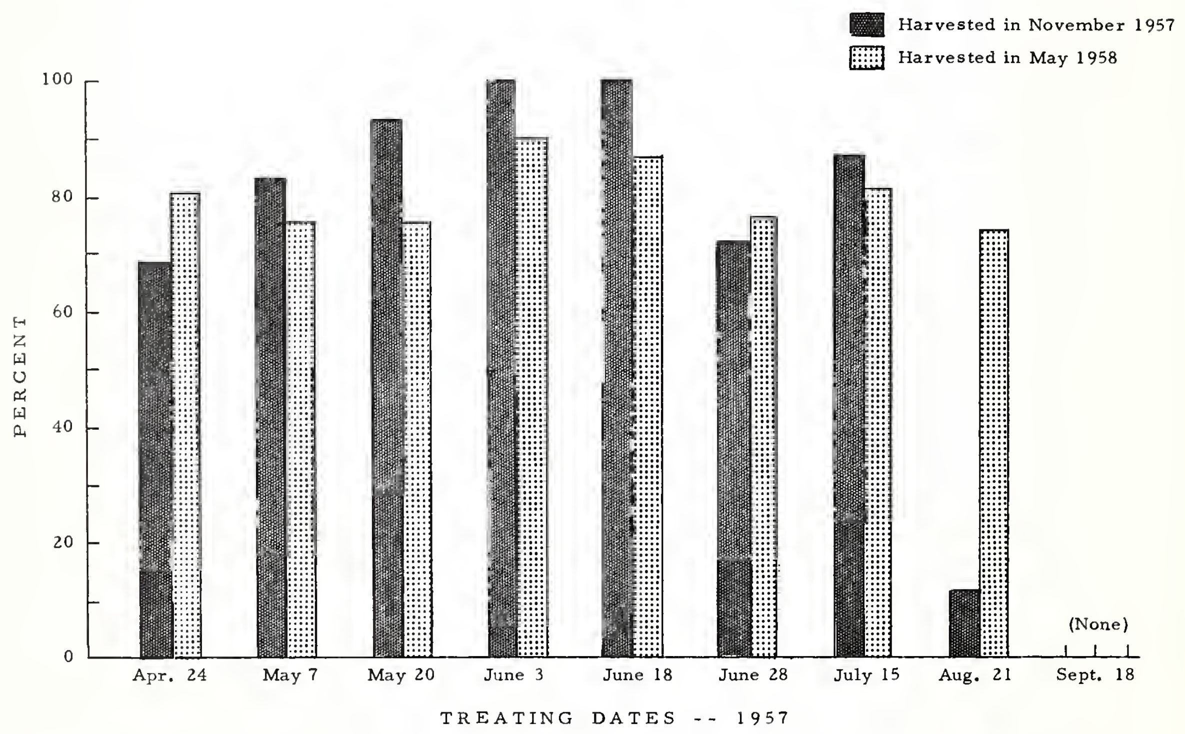
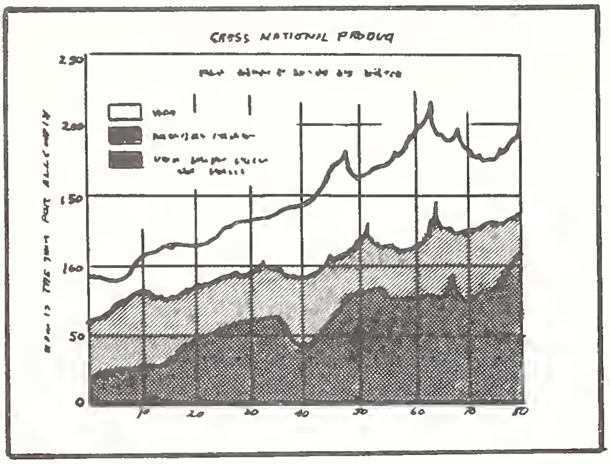


Figure U-9. --Percentage of treated bolts from Black Hills ponderosa pine that peeled as easy or easier than sap peeling (rating 5). Trees were poisoned with sodium arsenite on 9 different dates. Half of them were harvested in November 1957; the remainder in May 1958.



FOREST ECONOMICS RESEARCH

FOREST SURVEY

Inventory of timber volume completed on 7 million acres

In Colorado, volumes of timber were obtained by cruising sample plots on the Arapaho, Grand Mesa-Uncompahgre, Pike, and San Isabel National Forests, and on adjoining private forest land. Approximately 6 million acres of forest land was covered during the year, including about 3 million acres of commercial forest land.

In Wyoming, plots were cruised on the Bighorn National Forest, including about 826,000 acres of forest land, 700,000 of which is commercial.

Lumber production increasing in Colorado and Wyoming

A survey of the 1957 production of lumber and other primary wood products in Colorado and Wyoming showed that production was above the average for the past 5 years. Preliminary estimates of lumber production place the 1957 output at 188 million board-feet in Colorado and at 108 million board-feet in Wyoming. The survey was conducted cooperatively with the U. S. Bureau of Census. Reports for each State are being prepared for publication.

FOREST MARKETING

Markets for pulp and paper appear promising in Colorado

Study thus far of the current market for 15 major grades of paper indicates excellent opportunities for a pulp and paper industry in Colorado. Not only is the current total market, which would be served by the Colorado industry, 12 times in excess of current productive capacity within the area, but market increases of 36 percent by 1965 and 64 percent by 1970 are expected.

Market areas consisting of Colorado and surrounding States were analyzed. The 7-State and 13-State areas are shown in figure FE-1. Analysis of the 7-State area consisting of Colorado, Arizona, New Mexico, Wyoming, Utah, Nebraska, and Kansas revealed a market for paper and paperboard of almost 1,200,000 tons a year. This is equivalent to a mill capacity of 3,800 tons a day, assuming mill operations of 310 days a year. Current output capacity of the area is only 311 tons a day.

The 13-State market area, including in addition to the 7-State area, Idaho, Montana, South Dakota, Oklahoma, Nevada, and West Texas, revealed a total market equivalent to a mill capacity of 6,413 tons a day. The comparable figure for a zone of freight advantage around Colorado was 2,491 tons a day.

From a volume standpoint, newsprint, coarse paper, and special foodboard appear to offer especially interesting opportunities. The market for newsprint in Colorado alone requires a mill capacity of 238 tons a day, while in the 7-State area, the volume is nearly 3 times as great. The several grades of coarse paper require a mill capacity of 600 tons a day, and special foodboard a capacity of 186 tons a day.

In terms of growth, special foodboard leads all grades with an expected increase of 306 percent by 1970. Other grades showing increases in excess of the expected average are sanitary and tissue paper, paperboard, building board, and building paper.

Fifty-five percent of the 7-State area market was accounted for by the consumption of paper by printers, publishers, and converters. This market could be tapped by a mill whose operations were confined to the normal papermaking operations. Forty-five percent of this market is accounted for by imported converted

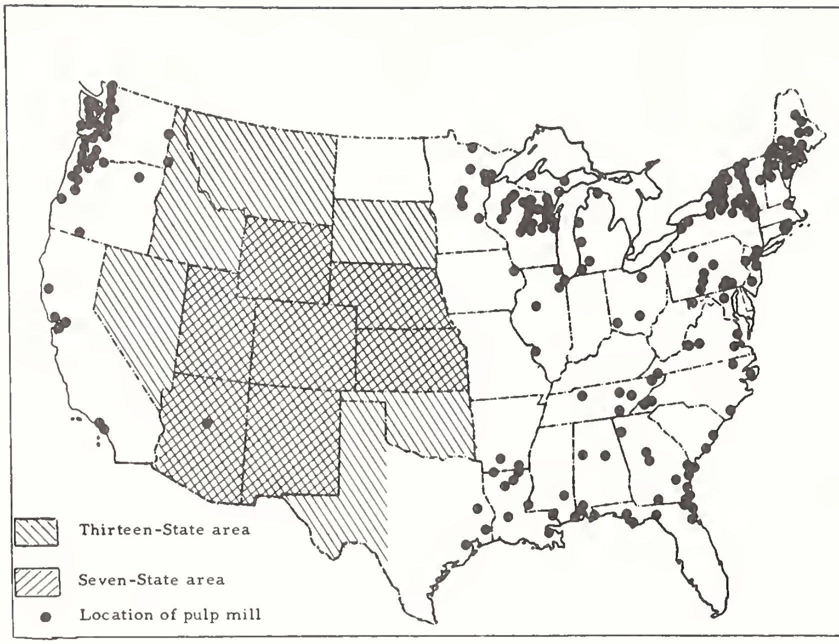


Figure FE-1. --U. S. woodpulp mills, 1956, in relation to 7- and 13-State market areas.

products. An expansion of the converting facilities within this area would be required to tap this market.

Table FE-1 shows the 15 grades of paper analyzed and the total current market in each of 3 market areas in tons a day of mill capacity.

Table FE-1. --Mill capacity required to satisfy the market in a 13-State area, 7-State area, and zone of freight advantage, 1957, in tons a day[1]

Products	13-State area	7-State area	Zone of freight advantage
	Tons	Tons	Tons
Newsprint	1,193	766	623
Printing paper	462	234	122
Fine paper	222	136	70
Coarse paper:			
Wrapping paper	114	72	56
Shipping sacks	192	137	76
Bags	273	160	127
Converter paper	242	146	125
Special industrial	147	88	72
Sanitary and tissue paper	450	260	236
Paperboard:			
Container board	1,214	756	377
Bending board	445	278	146
Special foodboard	342	186	57
Nonbending board	496	166	151
Building paper	285	203	124
Building board	336	240	146
Total	6,413	3,828	2,491

[1] Based on 310 mill-operating days a year.

FOREST BIOLOGY

(In cooperation with
U. S. Fish and Wildlife Service)

Pocket gopher control on Colorado rangeland

In 1958 the Denver Wildlife Research Laboratory, Bureau of Sports Fisheries and Wildlife, began a new study on the Black Mesa experimental area in western Colorado to evaluate the effectiveness of spraying 2, 4-D on mountain grasslands to control pocket gophers. Previous studies made in 1957 in cooperation with the Forest Service and the Colorado Agricultural Experiment Station had shown that pocket gopher populations were reduced following spraying grass-forb mountain ranges with 2, 4-D. Since the exact cause of this reduction was not determined, the new study was designed to find out why the population dropped.

Pretreatment information on population size, composition, and distribution was collected by live-trapping, leg banding, and map plotting of capture sites for each animal. Test areas were sprayed with 2, 4-D. The study of pocket gopher numbers and movements will be continued on these sprayed and unsprayed plots until definite conclusions become apparent.

Diet of pocket gophers

Personnel from the Denver Laboratory have completed the examination on 149 mountain pocket gopher stomachs collected from experimental pastures 1, 2, and 3 on Black Mesa. The stomachs were collected from late June through mid-September. Forbs made up 96.7 percent of the diet; grasses made up 3.3 percent. Stems and leaves of forbs and grasses (above-ground

vegetation) amounted to 72.5 percent of the food volume, and roots of forbs and grasses made up 27.5 percent. The six plants found most frequently in the stomachs were slenderleaf gilia (_Collomia linearis_), aspen fleabane (_Erigeron macranthus_), common dandelion (_Taraxacum officinale_), aspen peavine (_Lathyrus leucanthus_), lupine (_Lupinus_ spp.), and hairy goldaster (_Chrysopsis villosa_). These plants are not considered valuable cattle forage on mountain ranges.

Grazing effects

Pastures on Black Mesa are being grazed at three intensities: light, moderate, and heavy. Pocket gophers will be collected again to determine their food habits after the grazing treatments have progressed sufficiently to produce changes in the production, composition, and density of the pasture vegetation.

Also, pocket gopher mounds are being counted in the six experimental pastures to determine whether grazing treatments influence the number of pocket gophers. The mounds are counted each year in September. More pocket gopher mounds were recorded on the plots in 1958 than in 1957. There was also a general increase of mounding activity in all pastures. At this early stage in the investigation, the effect of grazing treatments on gopher numbers is not yet discernible. The average number of mounds thrown up per day on twenty 1/100-acre plots in mid-September on the Black Mesa experimental pastures was as follows:

Intensity of use and pasture number	1957 (No.)	1958 (No.)
Light		
2	14	24
4	11	26
Moderate		
1	23	24
6	20	32
Heavy		
3	9	26
5	19	27

Rodent trends on experimental pastures

Rodent trapping in the six experimental Black Mesa pastures has shown that the populations have varied with the years (table FB-1). The mouse population was highest in 1956. It was lowest in 1957. The 1958 figures showed an increase over the 1957 population.

Table FB-1. --Comparison of small rodent catch per 100 trap nights, Black Mesa experimental pastures

Intensity of use and pasture number	1954	1955	1956	1957	1958
			Number		
Light					
2 and 4	13.1	--	15.0	1.7	3.3
Moderate					
1 and 6	11.1	--	19.2	1.1	5.5
Heavy					
3 and 5	20.0	--	28.3	1.1	4.4
All pastures	14.7	--	20.8	1.3	4.4

The pastures were grazed as nearly alike as possible from 1954 through 1956. In 1957 and 1958 stocking rates were varied to get the different degrees of use. There was no apparent trend in mouse populations due to the intensity of grazing in the first 2 years of treatment.

Small rodent populations are also being studied in the pine-bunchgrass pastures of the Manitou Experimental Forest, where grazing treatments have been in effect for 17 years. No overall change was noted in the rodent catch on the inventory lines between 1958 and 1957. The take per 100 trap nights for all pastures was 4.35 animals in 1958 and 4.16 in 1957. The deer mouse was the most common animal caught, although meadow mice, golden-mantled ground squirrels, thirteen-lined ground squirrels, and chipmunks were also taken.

The cattle exclosures located in each pasture were inventoried for rodent numbers for the first time. More animals were taken per 100 trap nights in these non-used areas than in the pastures. Likewise, for the pastures themselves, more animals were taken in the lightly used pastures than in either the moderately or heavily grazed areas. The same trend was apparent in 1957.

A comparison of small rodent catch per 100 trap nights on the six pastures at Manitou Experimental Forest for 1957 and 1958 follows:

Intensity of use and pasture number	1957 (No.)	1958 (No.)
Cattle exclosure (non-use)	--	18.8
Light		
2 and 5	5.5	5.3
Moderate		
3 and 6	3.3	4.7
Heavy		
1 and 4	3.6	3.0

The exclosures contained more rodents, particularly meadow mice, than the pastures. The heavy ground cover in the exclosures affords better food and protection for meadow mice than does the lighter cover of the grazed pastures.

Rodent populations at Fraser vary

Rodent numbers on the strip-cut Fool Creek watershed dropped considerably from the population high of 1957. Only about one-fourth as many animals were taken on the inventory lines in 1958 as in 1957. The catch per 100 trap nights in 1957 was 24.6 animals; in 1958, the catch was 5.4. Redbacked mice and meadow mice were taken most frequently.

As in 1957, more animals were taken in the cut strips than in the uncut. However, the difference was not as pronounced with the low population in 1958. The number of animals taken in the cut strips was 6.4 per 100 trap nights; on the uncut it was 4.4. In 1957, about twice as many animals were caught in the cut strips (32.8) as were taken in the uncut (16.8).

In the adjacent untreated East St. Louis drainage, a drop in rodent numbers was also recorded in 1958. The take per 100 trap nights was 1.3 as compared with 6.6 in 1957. In both years the mouse population on the undisturbed East St. Louis watershed was much lower than on the strip-cut Fool Creek area.

The fresh logging slash on the cut strips provided abundant food for the rodents in the form of bark and cambium in the downed tops (figs. FB-1 and FB-2). This food supply will be lost, however, as the slash loses freshness and deteriorates. Logging slash also serves as a protective cover. These improved food and cover conditions have presumably favored rodent numbers on the treated watershed.

Figure FB-1. --Logging slash and young conifer reproduction provided favorable food and cover for rodents on the strip-cut watershed at Fraser.

PUBLICATIONS

Watershed Management Research

ALDON, E. F.
A wet year on Beaver Creek. Ariz. Wildlife-Sportsman 29(4): 22-23, illus.

Brief description of the Beaver Creek project and report of 1957 rainfall thereon.

BERNDT, H. W., and GIBBONS, R. D.
Root distribution of some native trees and understory plants growing on three sites within ponderosa pine watersheds in Colorado. Station Paper 37, 14 pp., illus.

Reports root distribution of 8 plant species on 3 different soils of the Colorado Front Range.

BROWN, H. E.
Gambel oak in west-central Colorado. Ecology 39: 317-327, illus.

Describes characteristics of oak brush stands and adjacent openings with particular reference to evidence concerning spread of oak brush.

CABLE, D. R.
Estimating surface area of ponderosa pine foliage in central Arizona. Forest Sci. 4: 45-49, illus.

Describes a method and presents equations for estimating the surface area of ponderosa pine foliage from oven-dry weight of pine needles.

DECKER, J. P., and TIO, M. A.
Photosynthesis of papaya as affected by leaf mosaic. Puerto Rico Univ. Jour. Agr. 42: 145-150.

Describes experiments establishing that papaya leaves showing visible symptoms of leaf mosaic have reduced photosynthetic capacity.

_______ and WIEN, J. D.
Carbon dioxide surges in green leaves. Solar Energy 2: 39-41, illus.

Describes experiments on CO_2 exchange by leaves of cottonwood and eucalyptus as measured with an infrared gas analyzer. Distinct insurges and outsurges were observed at the beginning and end, respectively, of periods of illumination.

_______ and WIEN, J. D.
Symposium on phreatophytes: An infrared apparatus for measurement of transpiration. Presented at Amer. Geophys. Union Pacific Southwest Region Mtg., Sacramento, Calif., February 1957. Phreatophyte Subcom. of Pacific Southwest Interagency Com. 32-41. (Abstract in Amer. Geophys. Union Trans. 38: 416, entitled "Time course studies of transpiration of tamarisk and eucalyptus.")

Describes an apparatus for direct and continuous recording of transpiration rate of individual intact leaves and twigs.

GARSTKA, W. U., LOVE, L. D., GOODELL, B. C., and BERTLE, F. A.
Factors affecting snowmelt and streamflow. U. S. Bur. Reclam. and U. S. Forest Serv. 189 pp., illus.

Relationships between snowmelt and the climatic factors of air temperature, humidity, wind, and solar radiation are exhaustively investigated and equations formulated. The best of these are used with characteristics of antecedent streamflow in a technique developed to forecast the shape of a day's snowmelt hydrograph. Comparisons are made with other techniques and the relation of the areal snow coverage of a watershed to the streamflow hydrograph is examined.

GOODELL, B. C.
A preliminary report on the first year's effects of timber harvesting on water yield from a Colorado watershed. Station Paper 36, 12 pp., illus.

Increases in streamflow have followed the removal of half of the mature timber from the watershed of a snow-fed stream. The spring flood peak was increased the first year after cutting and decreased in comparison with the control in the second year.

HORTON, J. S.
Inflorescence development in Tamarix pentandra Pallas (Tamaricaceae). Southwest. Nat. 2(4): 135-139, illus.

Describes the development of inflorescence of five-stamen tamarisk and demonstrates that flowers appear both on last year's wood and on the shoots developing in the summer.

LOVE, L. D.
High dams and upstream storage. Part 1B. Can watershed management alleviate the need for large storage projects? Mont. State Univ. Second Ann. Water Resources Conf. Proc. 1957: 14-21.

Outlines the results of forest, range, and watershed research in the central Rockies of Colorado. Points out how these activities supplement the need for large storage projects. The extent to which the streamflow hydrograph is altered by watershed management activities dictates the size of the projects.

SHAW, E. W.
Snow research in the Colorado alpine. The Prism, Colo. State Univ. Winter 1958: 11-13, illus.

Popular photo-story on the station's alpine research.

BOHNING, J. W.
Salting for better livestock distribution. Ariz. Cattlelog 13(5): 60-61.

Contrary to popular opinion, cattle do not go directly from salt to water, but may graze several hours between salting and watering if salt and water are some distance apart. Salt, or meal-salt mixture, placed on lightly grazed areas, aids in obtaining more uniform utilization. Best results in the southwest can be obtained during the cool months of the year when cattle water less frequently.

____
Who can afford to haul water? Amer. Hereford Jour. 49: 656-657, illus.

Discusses costs and benefits derived from hauling water to cattle on a southwestern semidesert range.

HURD, R. M., and POND, F. W.
Relative preference and productivity of species on summer cattle ranges, Big Horn Mountains, Wyoming. Jour. Range Mangt. 11: 109-114, illus.

Grasses and sedges are rated by preference, pounds of herbage produced, and pounds of forage produced. Idaho fescue is of major importance. Forbs supplied 8 percent of the forage.

JAMESON, D. A.
U. S. F. S. marks inaugural airlift onto remote G. C. mesa. Ariz. Daily Sun, May 17 issue, p. 5, illus.

A photo-story on the ecology of Fishtail Mesa in the Grand Canyon.

JOHNSON, W. M.
Reinvasion of big sagebrush following chemical control. Jour. Range Mangt. 11: 169-172, illus.

Big sagebrush seedlings were most numerous when 40 to 60 percent of the original stand was killed with herbicides.

Seedlings became established only in occasional years. Sagebrush seedlings were almost nonexistent on ranges ungrazed following sagebrush control.

_______ and REID, E. H.
Herbage utilization on pine-bunchgrass ranges of Colorado. Jour. Forestry 56: 647-651, illus.

The effects of different intensities of grazing on species palatability are discussed. Variations in utilization of important species as influenced by season are pointed out.

MAY, M.
Bibliography on deer-range relationships. Wyo. Univ. Range Mangt. Issue 115, 5 pp.

A list of references dealing with deer nutrition, competition with livestock, and seasonal values of forage plants for deer use.

PASE, C. P.
Herbage production and composition under immature ponderosa pine stands in the Black Hills. Jour. Range Mangt. 11: 238-243, illus.

Herbage production increased sharply as ponderosa pine crown cover decreased. Grasses and sedges showed greatest response to reduced crown cover, with forbs next, and browse least.

_______ and HURD, R. M.
Understory vegetation as related to basal area, crown cover, and litter produced by immature ponderosa pine stands in the Black Hills. Soc. Amer. Foresters Proc. 1957: 156-158, illus.

Herbage production decreased from 1,660 to 22 pounds per acre as basal area increased from 0 to 200 square feet. Grasses and sedges, while most abundant at all areas, showed greatest decrease.

PINGREY, H. B., and DORTIGNAC, E. J.
Range seeding -- what does it cost? Cattleman 44(12): 48-49, illus.

A brief summary of New Mexico Agricultural Experiment Station Bulletin 413, "Cost of seeding northern New Mexico rangelands." Gives the costs of seeding sagebrush-woodland rangelands in north-central New Mexico and on eroded cropland of northeastern New Mexico.

REYNOLDS, H. G.
Vegetational types in Arizona in relation to grazing use. Ariz. Cattlelog 13(5): 26-27, illus.

Dominant vegetation, growing conditions, grazing use, and grazing capacity are described for forests, woodlands, chaparral, grasslands, and desert shrub types of Arizona.

____
The ecology of the Merriam kangaroo rat (Dipodomys merriami Mearns) on the grazing lands of southern Arizona. Ecol. Monog. 28: 111-127.

Reports life history, habitat, and economic relations of the Merriam kangaroo rat to grazing lands. Direct and indirect effects of precipitation and good range condition tend to hold the number low. On ranges in good to excellent condition, seed-burying habits of these rodents are probably of beneficial influence. On rangelands infested by cacti and mesquite these same habits may favor accelerated spread of these undesirable plants.

_______ and TSCHIRLEY, F. H.
Mesquite control on southwestern rangeland. Cattleman 44(10): 44-45, 62.

A reprint of U. S. Department of Agriculture Leaflet 421. Discusses the detrimental effects of mesquite, the value of control, and types of stands most suitable for control by grubbing, basal oiling, mechanical clearing, and airplane spraying.

TURNER, G. T.
Outdoor lab converts grass into beef. West. Farm Life 60(6): 10, illus.

Summarizes results of grazing trials on Black Mesa during a 3-year period.

Forest Management Research

ALEXANDER, R. R.
Silvical characteristics of Engelmann spruce. Station Paper 31, 20 pp., illus.

Describes distribution, habitat conditions, life history, and properties and uses of Engelmann spruce.

____
Silvical characteristics of subalpine fir. Station Paper 32, 15 pp., illus.

Describes distribution, habitat conditions, life history, and properties and uses of subalpine fir.

GAINES, E. M., KALLANDER, H. R., and WAGNER, J. A.
Controlled burning in southwestern ponderosa pine: results from the Blue Mountain plots, Fort Apache Indian Reservation. Jour. Forestry 56: 323-327.

Indicates that fire may be useful in reducing excessive fuel, but points up need for more information on conditions under which it is feasible and on techniques for proper use.

________ and SHAW, E. W.
Half a century of research -- Fort Valley Experimental Forest 1908-1958. Station Paper 38, 17 pp., illus.

Briefly reviews the history and accomplishments of forest management research at Fort Valley, and mentions the problems ahead.

HERMAN, F. R.
Silvical characteristics of Rocky Mountain juniper. Station Paper 29, 20 pp., illus.

Summarizes the silvical information on Rocky Mountain juniper. The report includes a description of the species, its habitat conditions, growth habits, and uses.

MYERS, C. A.
Thinning improves development of young stands of ponderosa pine in the Black Hills. Jour. Forestry 56: 656-659, illus.

Precommercial thinning resulted in much better growth than occurred in similar, but unthinned, stands. It appeared that fewer trees should be left in the reserve stand than the numbers previously recommended.

_______ and VAN DEUSEN, J. L.
Estimating past diameters of ponderosa pines in the Black Hills. Research Note 32, 2 pp.

Presents a table for estimating past diameters at breast height when present diameter and radial wood growth for the period are known.

PETERSON, G. P.
Board-foot volumes of white fir to an 8-inch top. Research Note 30, 2 pp.

Presents board-foot volumes (Scribner) of white fir (Abies concolor) to an 8-inch top for merchantable heights of 1 to 7 logs and diameters outside bark of 12 to 50 inches.

READ, R. A.
The Great Plains shelterbelt in 1954. Nebr. Agr. Expt. Sta. Bul. 441 and Great Plains Agr. Council Pub. 16, 125 pp., illus.

A reevaluation of field windbreaks planted between 1935 and 1942 by the Prairie States Forestry Project in the "shelterbelt zone" of the Great Plains. Evaluates species survival, height growth, and vigor by site conditions; evaluates windbreak effectiveness by ratings; points out problems of design, location, and protection; and suggests research needs.

____
Silvical characteristics of plains cottonwood. Station Paper 33, 18 pp., illus.

Summarizes information on distribution, description, habitat, life history, natural enemies, and wood properties and uses of the plains cottonwood (Populus sargentii).

———. Trees for Nebraska windbreaks. Nebr. Farmer 100(7): 42.

Suggests best tree species for windbreaks on the basis of a 1954 survey of 15- to 20-year-old shelterbelts throughout the Great Plains.

WAGAR, J. A., and MYERS, C. A.
Some factors affecting the results of direct-seeding ponderosa pine in the Black Hills. Research Note 33, 6 pp., illus.

Results of a reexamination of 143 seedings on the Black Hills National Forest sown from 1905 to 1953. Adequate soil moisture was the key to seeding success.

Forest Insect Research

KNIGHT, F. B.
The effects of woodpeckers on populations of the Engelmann spruce beetle. Jour. Econ. Ent. 51: 603-607, illus.

Woodpeckers caused average reductions in spruce beetle populations ranging from 45 to 98 percent as the woodpecker feeding classification progressed from light to heavy. Beetle survival is correlated with the woodpecker feeding classification and the intensity of infestation in the tree.

———. Methods of surveying infestation of the Black Hills beetle in ponderosa pine. Forest Sci. 4: 35-41.

The ground survey method recommended for estimating numbers of ponderosa pine infested by the Black Hills beetle consists of parallel 1/2-chain-wide strips. Tables show predicted sampling errors for various combinations of the variables (acreage, survey coverage, and number of trees infested).

LANDGRAF, A. E., and OSTMARK, H. E.
Forest insect conditions in the central Rocky Mountains, 1957. Station Paper 34, 20 pp., illus.

Summarizes the status and trend of major forest insect pests in Colorado, Wyoming, South Dakota, Nebraska, and Kansas.

MASSEY, C. L.

Four new species of Parasitylenchus (nematoda) from scolytid beetles. Helminthol. Soc. Wash. Proc. 25: 26-30, illus.

Four new species of internal nematode parasites are described. Notes on their life histories are recorded.

SHAW, E. W.

The bark bug's enemy. Colo. Outdoors 7(4): 24-25, illus.

Popular article on how woodpeckers helped control the Engelmann spruce beetle in Colorado.

WYGANT, N. D.

Engelmann spruce beetle control in Colorado. Internatl. Cong. Ent. Proc. 4: 181-184.

Procedures and summary of accomplishments of projects from 1949 to 1955 that treated or logged 1,749,000 infested trees at a total cost of $4,803,000.

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